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Testing for collusion in bus contracting in London

Michael Waterson and Jian Xie

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# Testing for collusion in bus contracting in London

**Michael Waterson* and Jian Xie**

**University of Warwick**

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**Abstract**
We investigate the London bus market, a large market with regular procurement of bus services, for possible collusion using a wide variety of techniques, making use of the data at our disposal. There is little evidence of collusion in bidding for contracts apparent from our data, despite some features of the market that might lead to collusive behaviour.

JEL Nos.: D44, L41, L92, D22.

Keywords: Cartel behaviour, Procurement, Detecting Cartels, Bus market

*Corresponding author, Michael Waterson, Michael.waterson@warwick.ac.uk. We thank Estelle Cantillon for providing us with much background information on the tendering and her mixed bundling work relating to the London bus market, Elisabetta Iossa, Marleen Marra and Robert Munster for useful discussions or information, also discussion at a presentation at the Judge Business School, Cambridge on an earlier version. We are also grateful to various researchers who have gathered data used in the present project. Michael Waterson was involved as a Member in the Competition Commission market Inquiry into the British bus market, but this Inquiry related only to bus services outside London.

# 1. Introduction

Our aim in this paper is to test whether there appears to be collusion in the London bus tendering market, a market where many of the commonly-expressed conditions for collusion exist. However, we are agnostic as to whether it exists or not; we simply aim to use a wide variety of tests in our assessment given somewhat limited data.

Determining whether an industry is collusive is difficult, although there are some features that might point to it (Marshall and Marx, 2012). Essentially, there are structural and behavioural methods of doing this (Grout and Sonderegger, 2005) where structural methods are likely to be very wasteful (Harrington 2008) and behavioural methods require significant data, together with some assumptions. In particular, behavioural methods commonly require an assumption that the investigator is cleverer than the colluders in determining whether they will appear to be colluding, in circumstances where both the payoff to escaping undetected and the penalty for being caught are substantial. Of course, if there is suggestive evidence or insight that collusion is taking place, it is easier to obtain evidence confirmatory of its presence and so tie down who the perpetrators are. Hence, many of the papers on collusion draw on circumstances where it was legal.

It is often claimed that procurement contracts are fertile grounds for collusion, and there are several successful examples in the economics literature of researchers uncovering collusive schemes. Amongst these, important case studies include those of Porter and Zona (1993, 1999) on contracts for milk and for paving, and Bajari and Ye (2003) on “seal coating” in highway contracts. The reasons why procurement contracts are collusion-prone include the facts (i) that commonly, demand is price-inelastic, the procurer is sure to want the object of the exercise, (ii) that there will be a single winner whose identity will be clear will be clear, meaning there is no doubt that if the cartel arranged who would win and this did not happen, a deviant will be identified, and (iii) that a significant amount of information regarding the bids is normally published once the outcome has been determined (Whinston, 2006; Albaek et al., 1997). Moreover, in cases of repeated procurement, punishment is possible through subsequent rounds (Chassang and Ortner, 2018).

This extensive availability of data facilitated the investigations of Bajari and Ye and Porter and Zona. It is useful to illustrate using the Bajari and Ye example, see equation (1) below.

$$\frac{BID_{i,t}}{EST_{i,t}} = \beta_{i0} + \beta_{i1} LDIST_{i,t} + \beta_{i2} CAP_{i,t} + \beta_{i3} MAXP_{i,t} + \beta_{i4} LMDIST_{i,t} + \beta_{i,5} CON_{i,t} + \varepsilon_{i,t} \quad (1)$$

For their sample of contracts, to explain the bid values they had available an engineering estimate of the cost (EST), were able to estimate the capacity (CAP) of the firm utilised (i.e. how much work that they had in train compared with the total they were capable of doing) at the time of bidding, the capacity of their rivals (MAXP), the (log) distance of their plant and rivals' plant to the contract in question (LDIST and LMDIST) and familiarity with the area (CON). If the firms are bidding independently, and the fit of the estimated equation is good, there should not be any correlation between the estimated residuals of the various firms' contracts (epsilons). Through this means, and through pooling the regressions and testing for the legitimacy of pooling, they were able to identify two candidate partial cartel arrangements involving in total three of the 11 bidding firms they studied. We have less complete data on individual procurement outcomes, since we know only the winning bid, the identity of that bidder, the number of bids and the least competitive bid. Therefore we are only unusually able to observe switching between second and third bidders in successive rounds, an approach suggested by Kawai and Nakabayashi (2014). However we do have a relatively large number of cases and are able to take advantage of the fact that a significant number of contracts have been let for essentially the same object at different times.

The plan of our paper is as follows. We first discuss the London bus market in general, to set the scene and alongside this describe our data, then in subsequent sections discuss the hypotheses we will test, carry out the tests, and finally conclude. To summarise very briefly, we find very little evidence of active collusion in the market.

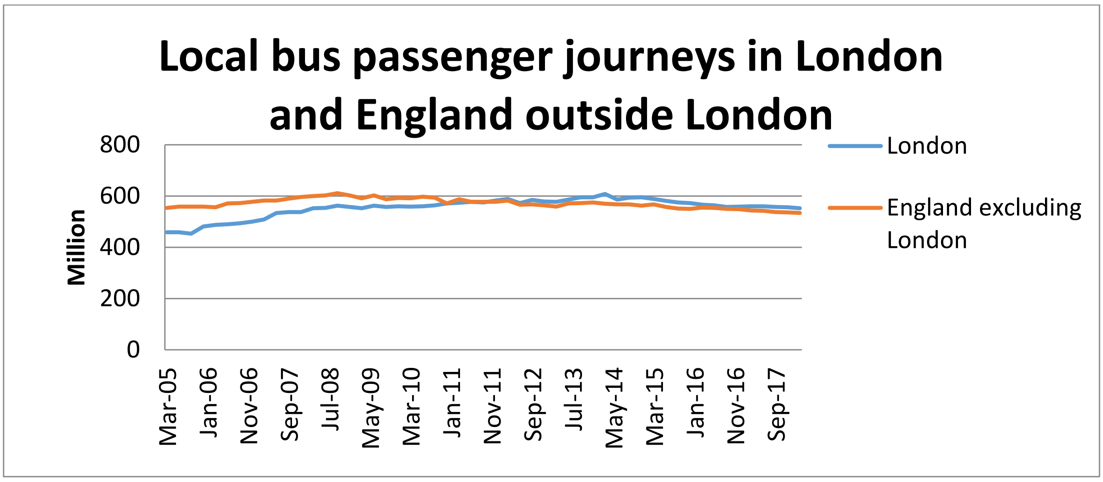
## 2. The London bus market

### 2.1 General description

The London bus market is a huge market. Based on the data from Department for Transport, in the year ending in March 2017, there were around 10200 buses in use and a total of 2.24 billion bus passenger journeys were made in London. This amounted to more than a half of the 4.44 billion passenger journeys made by local bus in England in 2016/17. Every weekday over 7,700 scheduled buses run on 675 different routes, with over 120 of those routes run 24 hours a day, seven days a week[1]. Figure 1 and Table 1 illustrate this.

[1] London's Bus Contracting and Tendering Process, Transport for London, 2015.

Figure 1: Local bus passenger journeys in London and England outside London




Source: Quarterly data from Department for Transport

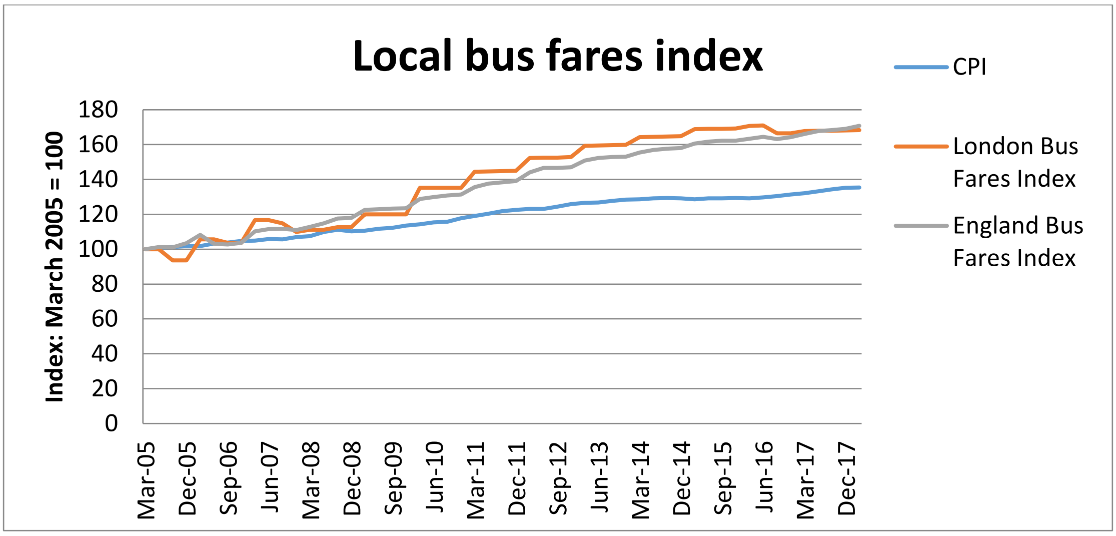
Table 1: Some statistics concerning the London bus market

| Year | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 |
|---|---|---|---|---|---|
| Kilometres operated(millions) | 491 | 489 | 492 | 495 | 490 |
| Schedule operated (percent) | 97.7 | 97.1 | 97.2 | 97.4 | 98.1 |
| Excess wait time (minutes) | 1.0 | 1.1 | 1.2 | 1.1 | 1.0 |
| Customer satisfaction (score) | 83 | 85 | 86 | 86 | 86 |

Source: Data from TfL annual report, excess wait time only relates to routes styled “high frequency”.

From March 2005 to March 2018, local bus fares in London have increased by 68.4%, much higher than CPI over the same period. The English bus fares index has been rising steadily at almost the same speed year over the years. However, it is important to note that the operators of buses within the Transport for London area do not rely on farebox revenue directly; a distinct contrast with buses outside London.

Figure 2: Local bus fares index




Source: Quarterly data from Department for Transport

The London bus is the subject of a complex and extensive operation in tendering. Transport for London (TfL) organizes tender competitions and specifies the route, frequency, vehicle quality and service quality. Operators bid for the contracts, and they are asked to provide a schedule to deliver the level of service specified, and their tender price for providing the service to this specification. All tenders are submitted on a sealed bid basis with all the relevant information for the evaluation.

Almost all the routes operate on gross cost sealed-bid contracts lasting five years, with possible extensions to seven years, subject to performance. TfL has a continuous programme of tendering throughout the year. Contracts are put out to tender every two to three weeks, on a rotating basis. The rate of tendering is about 15% to 20% of London's bus network each year. The size of route tendered could be very different, with Peak Vehicle Requirements (PVR) ranging from 1 to over 50. Vehicles used could be 40 capacity midi-buses through to 87 capacity double deck buses on different routes. The choice of routes tendered on a particular date is not random. Routes in a similar area of London are often issued together. Operators are free to suggest alternatives which vary the service, alongside fully compliant bids, and a common feature is that they submit package bids covering more than one route. TfL normally choose the tenderer with the lowest gross cost, and if they do not, they will say why. In their report on the tender, they list the winner, the winning bid, the breakdown if it is a package bid, the number of bidders and the size of the least competitive bid, but they do not name the other bidders, nor intermediate bids. The bid itself is a fixed number of pounds required to provide the service for the first year. The contract commences some months after the award is announced, because the winner may need to acquire buses and drivers to fulfil the contract.[2]

[2] For the most part, the winning operator is required to buy or lease their buses as well as procuring the maintenance facilities

TfL sets fares and retains the revenue through a centralised system. The gross bid price quoted is subject to a formula-driven annual increase over the life of the contract incorporating an efficiency element. The formula is based on a few key cost elements. Fares are paid using contactless cards, so the driver does not need to handle cash. In addition, there are quality payments that could go in either direction. If the service quality provided by the operator is significantly lower than the requirement, then the payment should be from the operator and vice versa.

### 2.2 Our Data

The TfL website has, since 2003, listed the outcomes of all tenders by route, including date of award, the name of the winner, the overall bid price and equivalent price per mile, the number of bids, the least competitive bid, any information pertaining to package bids (called joint bids), and a reason for not awarding to the lowest bidder if that was the case. This information from 2003 to 2015 forms the core of our data-set, a total of 882 contracts.[3] In order to illustrate the dynamics of prices, for many purposes we only select the instances of routes for which the contracts have been let more than once over this period. Otherwise it would be very difficult to compare the price across routes because there are too many factors to consider. We have 402 such cases. In this paper, every time we mention price (cost) per mile, it has been adjusted by the relevant price index. Here we compare the price (cost) per mile of the same route in the first contract and in the second contract. In order to do this, the price per mile in the first contract must be uprated to the second date according to the formula for cost increases between those dates.[4]

In addition to this data, we are able to take advantage of enthusiasts' preparation of various tables, including listings of "peak vehicle requirement", being the number of buses required to run a route at peak times given normal service, market share calculations in terms of total bus numbers operated by a company, listings of garages (essential for maintenance and stabling of buses) by company, listings of route start and end points, and various other miscellaneous information.

Using the data on garages and buses (specifically, postcodes), together with a mapping program, we have been able to calculate empty-running time distance from the operator's nearest garage to one or other end of the route in each case, together with the time distance for other operators on that same route.

[3] We deliberately exclude routes with numbers starting 600, since these are almost all school services and thus run only twice per day. We also exclude night bus routes (coded N) that do not correspond to day routes, since again these comprise only 4 or 5 services per night.

[4] The formula is given in a publicly-available document released through a previous FoI request on a form contract which is filled in with appropriate operator details. Notice incidentally an interesting trade-off for an existing operator offered the opportunity to extend a 5-year contract into a 7-year contract- they have the certainty of an uprated price fixed over years before, versus the opportunity to win the contract for a further 5 years on new terms.

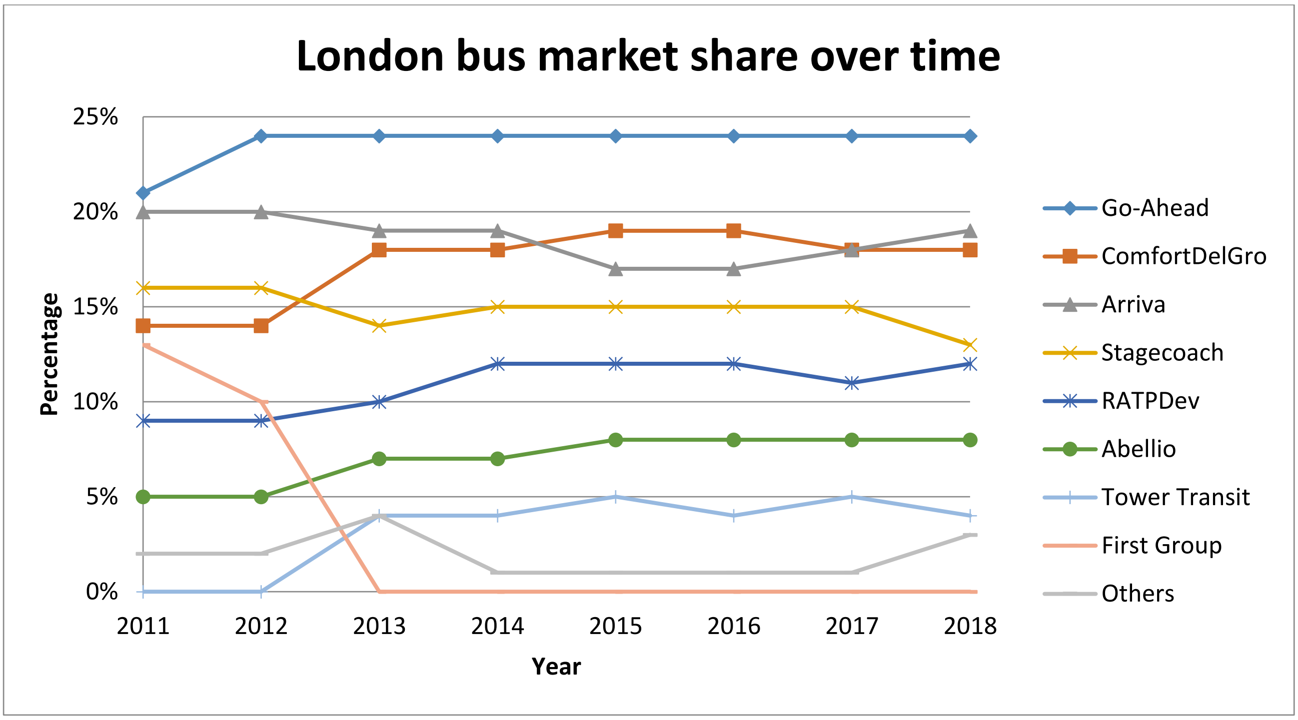
Finally, we have information relating to the sale by First Group of its operations, including the assets acquired and price paid by both successors.

### 2.3. Market shares and prices over time

The market share of London bus market changes somewhat over time. Every year TfL issues some routes for tender. New entrants have arrived in the market and existing companies have exited. Stagecoach left the market and sold its subsidiaries, namely East London Group and Selkent, to Macquarie Bank in 2006. But four years later, it reacquired its old London operations with all operations once again rebranded as Stagecoach London. First Group quit the London market over the 2012 to 2013 period, selling its operations in two portions to Metroline (an existing company also called ComfortDelGro,[5] based in Singapore) and Australian operator Transit systems (Tower Transit, an entrant).  Transdev owned two bus companies, London United and London Sovereign. They were sold to RATPDev in 2011 and 2014 respectively. National Express was in London market some years ago but left. Thus, it is worth noting that of the "big 5" operators in Britain, only three (Go-ahead, under a variety of names, Arriva, now a subsidiary of DB, and Stagecoach) operate in London, and many of the other large operators are subsidiaries of overseas companies. Figure 3 illustrates market share movements.

[5] We use the latter name, since there is a subsidiary of GoAhead called Metrobus, which is somewhat confusing.

Figure 3: London bus market share over time




Source: Data from annual reports of Go-Ahead for 2011 to 2017, data of 2018 is from July using the website: http://www.londonbusroutes.net/garages.htm. ComfortDelGro is the company behind Metroline, RATPDev is a French company and Abellio is the Dutch railway operator. Prior to 2011, company names were often different, making it difficult to track the nature of operators.

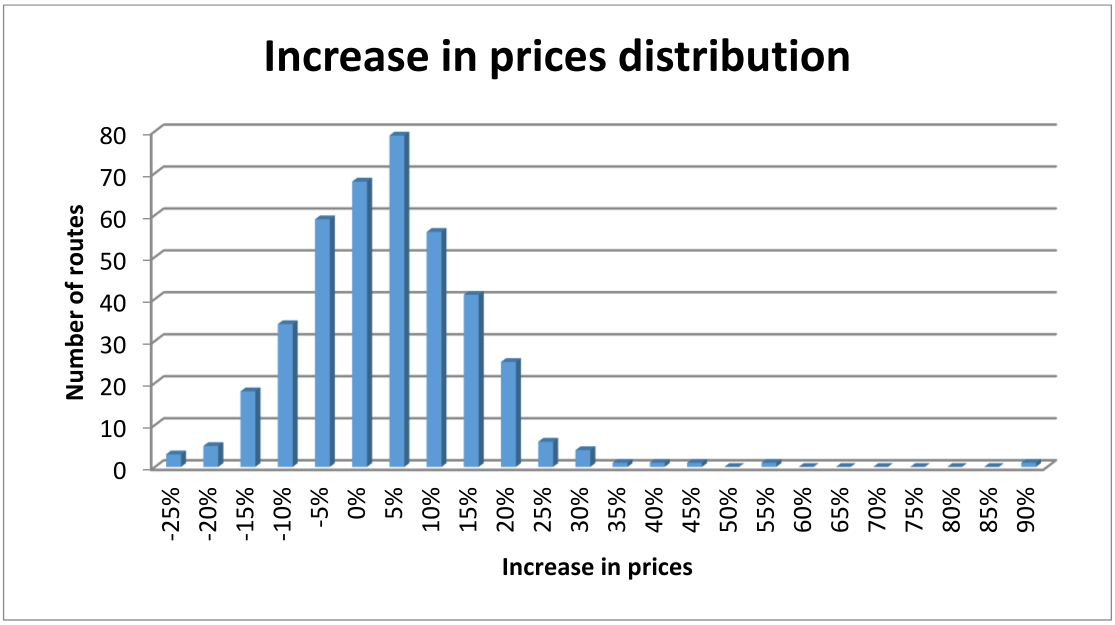
As we can see from figure 3, In 2018, Go-Ahead, ComfortDelGro, Arriva, Stagecoach and RATPDev in total occupy a market share of about 85%. The market share of Go-Ahead has been the biggest for more than 9 years, increasing from 21% in 2011 to 24% in 2012 and remaining stable since then. Previously, Arriva was the second largest bus company in London, but its market share has decreased from 2011 to 2015, losing its position for three years. But in 2018, it caught up with ComfortDelGro and became the second largest again. ComfortDelGro has expanded its business, its market share was 14% in 2011 and 18% in 2018, while the market share of Stagecoach has declined from 16% in 2011 to 13% in 2018. For smaller companies like RATPDev, Abellio and Tower Transit, their market shares have increased in general. Although Go-Ahead has been the largest bus company in London bus market for many years, its market share has never been higher than 25%. This is because bidders can be automatically disqualified if their market share exceeds 25% after winning the bid[6].

Between first and second contract periods, the price per mile of 54% of the routes has increased, while only 29% of the routes became cheaper. On average, price increases by 3.9% in the second contract compared with the uprated price in the first contract. From the increase in price distribution, figure 4, it is apparent that increasing by 5% is most common practice. The average price increase could have resulted from the

[6] See Amaral et al. (2013, p.6). However, we have been unable to trace the source of this information.

improvement of quality or weakening competition. From 2003 to 2015, bus quality is rising on average. For example, in 2006/07, only 23% of the London buses were fitted with an Automatic Vehicle Location (AVL), while by 2015/2016, 99% were, enabling improved tracking of punctuality and real-time reports to customers. But does the quality improvement account for all the price increase? We have no clear answer, since quality is reported only annually, and so many factors change from year to year.

Figure 4: Increase in prices distribution between successive contracts for the same route



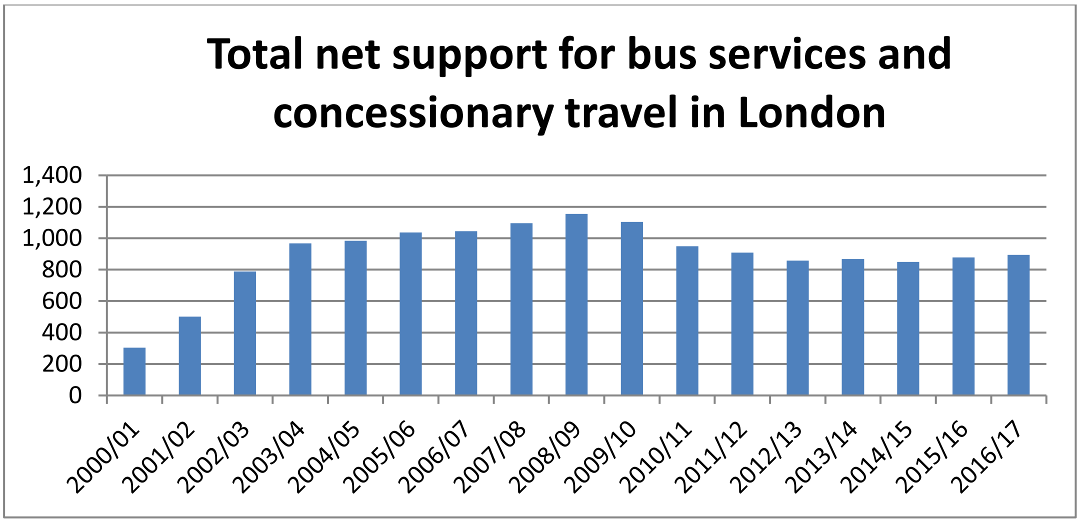

Source: Iossa and Waterson (2019)

### 2.4 Profitability over time

Bus services receive government support in different ways, including bus transport support, Bus Service Operators Grant (BSOG) and concessionary travel reimbursement.[7] They are important parts of the total revenue for bus businesses. The total net support paid in London in 2016/17 was around £894 million. In England outside London, the number was £1313 million in the same year. Of course, it is commonly the case that bus services, particularly urban bus services are subsidised.

[7] Concessionary travel is off-peak travel by those over pension age, which is normally free. In calculating the reimbursement, account is taken of generated traffic, so it is reimbursed at a fraction of the full fare. Hence the reimbursement is considered to be on a no-detriment basis, rather than being a subsidy.

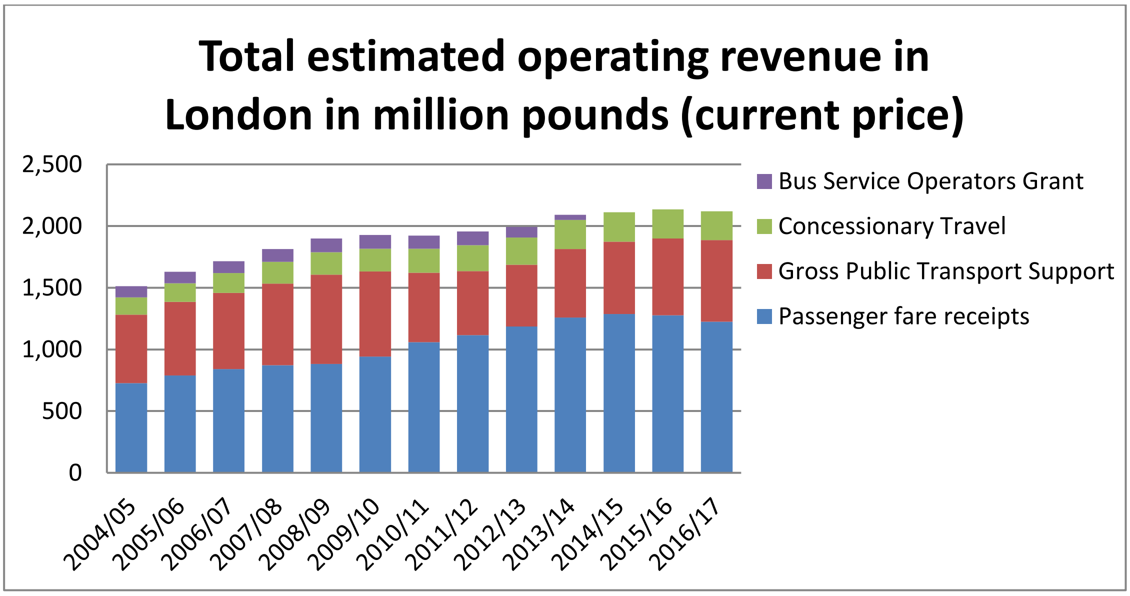
Figure 5: Total net support for bus services and concessionary travel in London




Source: Yearly data from Department for Transport, 2016/17 prices in million pounds.

In London, the total estimated operating revenue for local bus service was £2.12 billion in 2016/17. It has increased by 40% in real terms between 2004/05 and 2016/17. Passenger Fare Receipts is the largest part of the total revenue all the time. In 2016/17, it accounts for about 58% of the total revenue. Gross Public Transport Support and Concessionary Travel account for 31% and 11% respectively.

Figure 6: Total estimated operating revenue in London in million pounds (current price)




Source: Yearly data from Department for Transport., Public transport support is the payment from local authorities, mostly for running supported services. Concessionary reimbursement is from Las for carrying concessionary passengers. Bus Service Operators Grant was a partial fuel duty rebate.

Figure 7a: Operating profit and margin of Go-Ahead in the London bus market

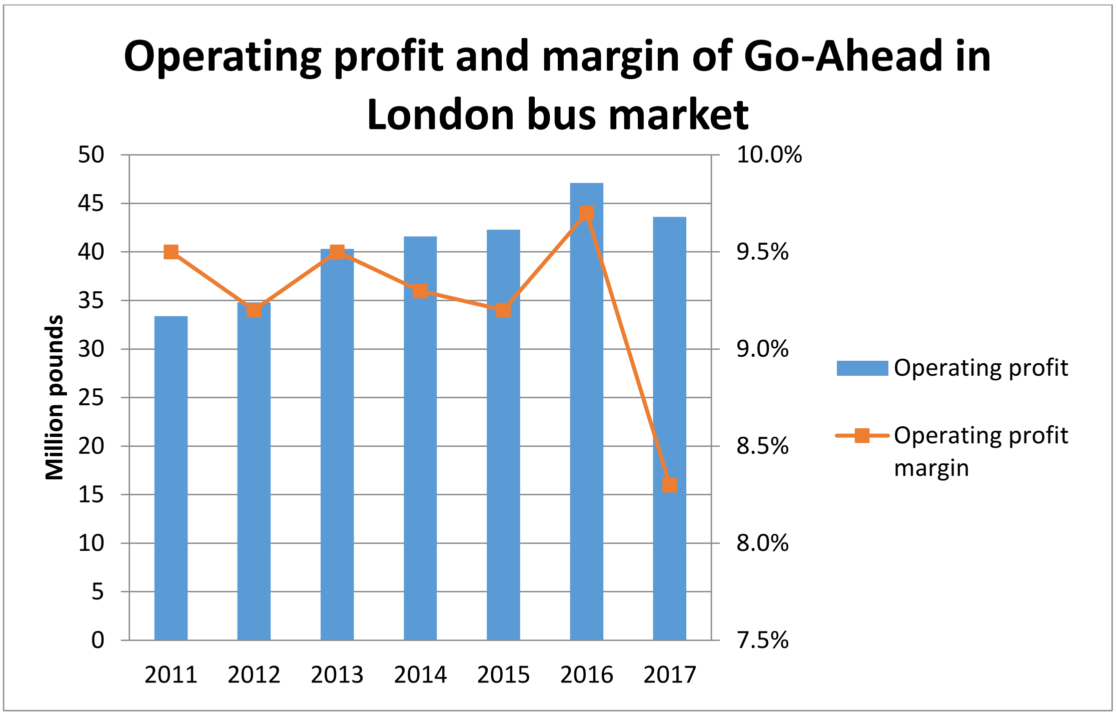



Figure 7b: Operating profit and margin of ComfortDelGro in the London bus market

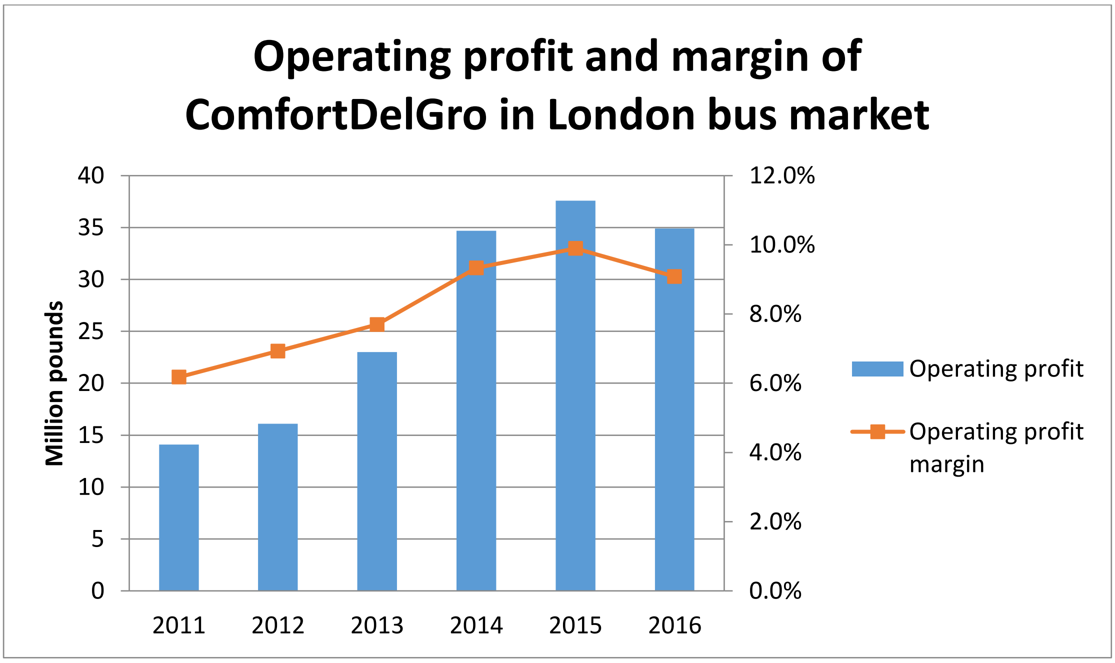
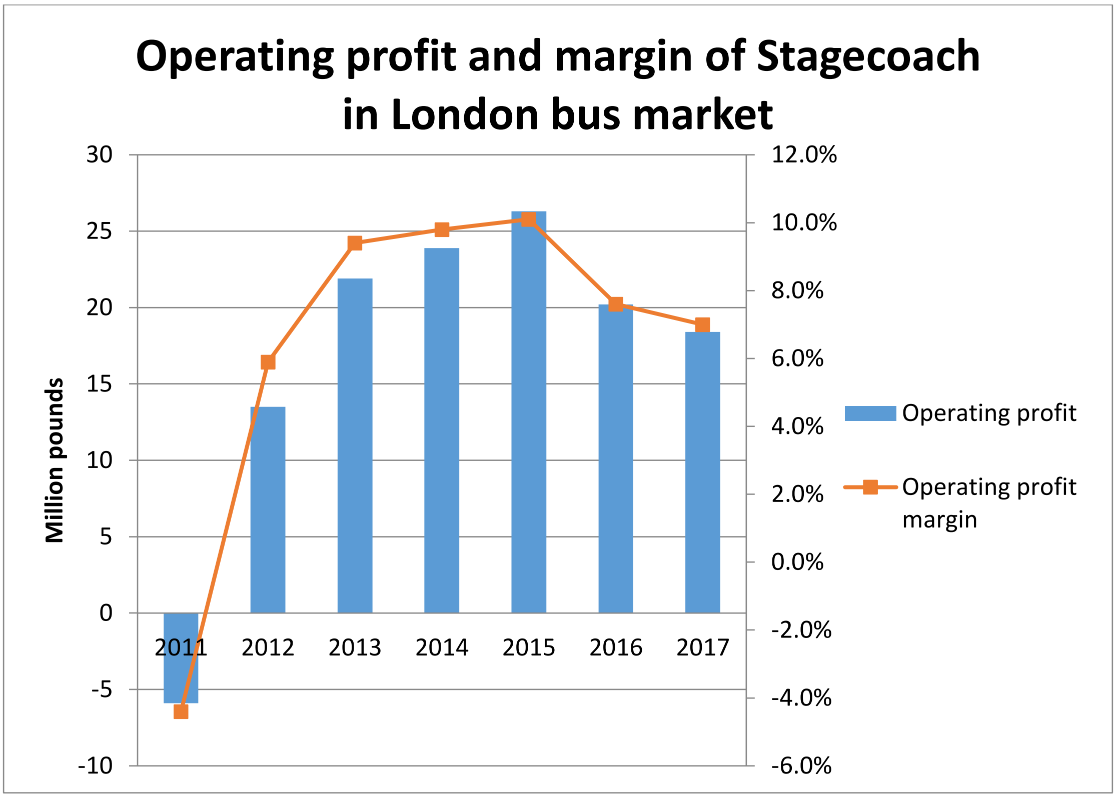


Figure 7c: Operating profit and margin of Stagecoach in the London bus market




Sources: For the three figures above, all the data is from their annual reports respectively. Where the figure is revised in a later annual report, the latest figure is taken.

It is not possible to calculate the operating profit for the London bus market as a whole. However, some of the companies report separate accounts for their London operations and Figure 7 captures the picture. Operating profit margins are variable and not excessively high. Go-Ahead seems to have gone for a strategy of growth followed by consolidation; ComfortDelGro's market share and operating profit margin have been trending upward. Stagecoach suffered an operating loss of £5.9 million in 2011. According to its annual report, the loss of £5.9m is after taking account of (i) a £3.2m release from the provision that was recorded at acquisition in respect of acquired customer contracts and (ii) £9.9m of costs in relation to rebasing of staff terms and conditions. From 2012 to 2015, both the operating profit and the margin increased remarkably. In 2016, the operating profit of Stagecoach has dropped by 30% compared with the last year. Their explanation in the annual report is that they tried to bid prudently for the long-term sustainability of the business, so they lost some contracts with TfL.

**2.5 Prices paid by new entrants**

We seek to compare prices paid to new entrants and prices paid to incumbents. Here, we define a new entrant as a company winning a contract for a route that previously belonged to another company. If a division or a subsidiary of a company wins a contract of a route from another division or subsidiary of the same company, we also define this division or subsidiary as a new entrant. By contrast, an incumbent is a company wining the contract for the same route for the second time with the same name. In our data set from 2003 to 2015, we have 402 cases in total where the same bus service was tendered twice within the period. Among these, 204 were won by a company with the same name. with 198 others. On average, new entrants win the tender with 4.5% price increase while incumbents win the tender with 3.2% price increase in real terms, using the uprating formula discussed earlier.[8]

What caused the higher average cost of new entrants? After some examination, we find that among the 198 new entrants, 124 (or 62.6%) show a rise in price. For the 204 incumbents, 130 (or 63.7%) show a rise in price, so that more of the incumbents increase their prices; see Table 2. However, both the minimum and maximum values of new to old contract price of new entrants are higher than those of incumbents, especially the maximum value. So the higher average cost of new entrants partly stems from the outliers. Actually, if we exclude the five outliers that are higher than 1.323, the average price increase would be 3.3% for new entrants, almost the same as that of incumbents. Consequently, without these outliers, entrants would win auctions at similar cost increases to incumbents.

Table 2: Price change information for new entrant and incumbent

| | New Entrant | Incumbent |
|---|---|---|
| Observations | 198 | 204 |
| Percentage of cases increasing price | 62.6% | 63.7% |
| Mean value new to old contract price | 1.045 | 1.032 |
| Average price increase | 4.5% | 3.2% |
| Min value new to old contract price | 0.792 | 0.733 |
| Max value new to old contract price | 1.894 | 1.323 |
| STDEV of new to old contract price | 0.130 | 0.106 |
| | | |

Note: Price increase = (new to old contract price – 1)x100%, with the new contract price being uprated according to the price index that prevails in-contract.

## 3. Testing for collusion in bus contracting in London

We regard collusion as a form of reciprocal agreements among bidders, either explicit or implicit, to limit competition and improve participants' welfare. Why might collusion exist in the London bus market? First, the number of bus companies is limited in London, especially after 2009, with only about 10 operators. They have plenty of opportunities to communicate with each other. Second, the winning bidder and its price will be published publicly by TfL, so that cartel members, if any, can detect deviation

[8] Recall that by "price" we mean cost per mile of the winning bid.

from their previous agreements. Third, the products provided by different bus companies are relatively homogeneous because many of the dimensions are set by TfL. Bus companies compete largely on price. If every firm agrees to propose a higher price in their bid, it benefits all of them.

We use a variety of different methods based on our data set to test collusion in bus contracting. However, some of the approaches proposed by previous researchers are not available, given the nature of our data. In particular, not knowing the identity of the losing bidders, nor their bids (unless there are only two bidders) means we cannot use the approach employed by Bajari and Ye (2003), nor can we assess the closeness of non-winning bids to each other (Marshall and Marx, 2012). Nevertheless, by using a wide variety of methods that are available, we can obtain a reasonable picture of the likelihood that firms are colluding in their bids. We discuss these methods and the hypotheses we employ in the subsections below.

### 3.1 Auctions with only one bidder

Auctions with only one bidder are suspicious because they could result from collusion. Some of the bus companies in a particular area of London might discuss allocation of the routes and determine which one should win which contract before the auction, while others voluntarily quit. It is easy to manipulate. The only bidder could give a high cost. We will test this hypothesis based on the data we have as follows.

**Hypothesis 1: Auctions with only one bidder result from collusion among operators. They manipulate before the bidding process and only one of them participates in the bidding, leading to a higher than normal price winning the contract.**

In our sample, we have 64 auctions with only one bidder. 48 of them are tendered for the first time while 16 of them are tendered for the second time in the period from 2003 to 2015. Among the 64 auctions, the average cost per mile is £4.71, 26.3% higher than the sample average £3.73. What caused the high cost of these auctions? We ranked the cost per mile among the 64 auctions to find that there were four obviously expensive auctions with cost per mile more than £8.50. Two of them concern route 143D and another two are for route B99 (Both routes have been tendered twice). These are both very short routes, among the 10 shortest routes in our whole sample. They are less than 6 thousand miles per year, while the sample average is about 533 thousand miles. Therefore, we investigate whether the high cost per mile results from these four expensive auctions relates to their very limited nature.

More generally, we performed a regression to investigate whether route length affects cost per mile or not. As indicated in Table 3 below, route length is negatively associated with cost per mile, t-statistic is very significant, which means the cost per mile of shorter routes is statistically higher.

Table 3: Regression to investigate whether route length has an impact on cost per mile

| Variable | Coefficient | t-statistic | Significant level |
|---|---|---|---|
| ln(miles) (million) | -0.619 | -10.64 | 1% |
| number of bidders | -0.183 | -4.05 | 1% |
| joint | -0.078 | -0.72 | Non |
| year | -0.001 | -0.09 | Non |

Note: 882 observations, cost per mile is the dependent variable, any 'cost per mile' in this paper has been adjusted by price index. Control variables include number of bidders, whether it is a joint bid and different years.

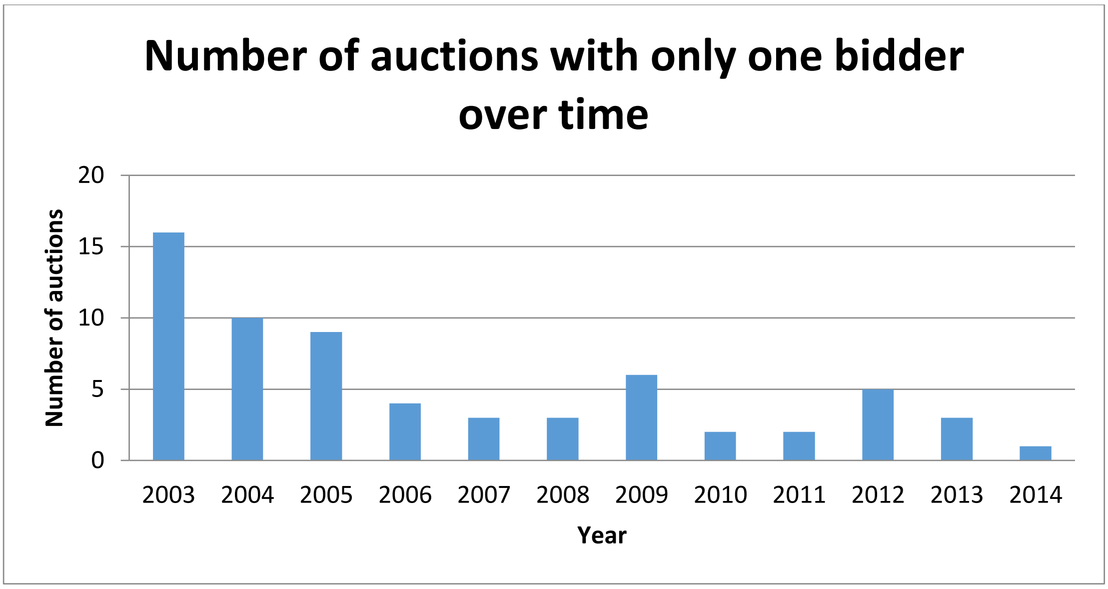
Second, we checked the average cost per mile of routes less than 100 thousand miles. There are 54 auctions and their cost per mile is £5.74, 53.9% higher than the sample average. Then we examined the average cost per mile of routes shorter than 50 thousand miles, it is £6.96, even more expensive. Therefore, for very short routes, they are indeed more expensive per mile in general. Among the 64 auctions with only one bidder, if we exclude the four auctions associated with routes 143D and B99, the average cost per mile for the other 60 auctions is £3.95, not too expensive compared with the sample average.

On the other hand, price increase in the same route could be a better indicator because different route has different idiosyncrasy, which might lead to a different cost. So, we now focus on the 16 contracts that have been let again. We find that 15 of them were won by old suppliers, only one of them was won by a new supplier. For the 16 cases, 9 of them show a rise in price, 7 of them show a drop in price. And the average price increase is 1.2%, lower than the sample average 3.9%. If there was any collusion within those 16 cases, we would expect obvious price increase. Consequently, we cannot conclude that collusion exists here.

**Proposition 1: There is scant evidence supporting the existence of collusion among auctions with only one bidder. Other factors may affect the participation rate of these auctions.**

Maybe there have been some efforts made by TfL to avoid auctions with only one bidder. We can observe from Figure 8 below that this trend has been decreasing. In 2003, there were 16 auctions with only one bidder, while in 2014, there was only one. We can anticipate that this form of collusion by agreement not to bid could be harder and harder.

Figure 8: Number of auctions with only one bidder over time




**3.2 Collusion by market sharing**

In section 2.3 we analysed market share over time. Is it possible that the major operators collude by market sharing? One common reciprocal market sharing agreement is that participants commit not to enter each other's territory in procurement auctions leading to a very stable market share and very low churn. Another kind of market sharing agreement is that operators agree to exchange contracts. For example, company A loses bids to company B on some routes, while it takes over some other routes from company B, resulting in a relatively stable market share but with some contracts changing hands. Hence the two hypotheses:

**Hypothesis 2A: Operators collude in staying away from each other's territory in procurement auctions.**

**Hypothesis 2B: Operators collude to exchange contracts to guarantee their market share.**

In this section, we use our data set to examine these two forms of collusion by market sharing. We choose the data involving Go-Ahead, Arriva and ComfortDelGro because they are representative companies and they have remained in the London market over the last 15 years. The relevant data is displayed in Table 4 below:

Table 4a: Different types of contracts involving Go-Ahead that have been tendered twice

| Types | Winner for the first time | Winner for the second time | Number of contracts |
|---|---|---|---|
| Type 1 | Go-Ahead | Go-Ahead (same division) | 59 |
| Type 2 | Go-Ahead | Go-Ahead (different division) | 7 |
| Type 3 | Go-Ahead | Other companies | 15 |
| Type 4 | Other companies | Go-Ahead | 31 |

Table 4b: Different types of contracts involving Arriva that have been tendered twice

| Types | Winner for the first time | Winner for the second time | Number of contracts |
|---|---|---|---|
| Type 1 | Arriva | Arriva (same division) | 62 |
| Type 2 | Arriva | Arriva (different division) | 0 |
| Type 3 | Arriva | Other companies | 24 |
| Type 4 | Other companies | Arriva | 9 |

Table 4c: Different types of contracts involving ComfortDelGro that have been tendered twice

| Types | Winner for the first time | Winner for the second time | Number of contracts |
|---|---|---|---|
| Type 1 | ComfortDelGro | ComfortDelGro (same division) | 31 |
| Type 2 | ComfortDelGro | ComfortDelGro (different division) | 0 |
| Type 3 | ComfortDelGro | Other companies | 8 |
| Type 4 | Other companies | ComfortDelGro | 10 |

Table 5: Number of contracts these three companies lost to each other

| 2nd \ 1st | Go-Ahead | Arriva | ComfortDelGro |
|---|---|---|---|
| Go-Ahead | 59 | 12 | 0 |
| Arriva | 1 | 62 | 0 |
| ComfortDelGro | 1 | 2 | 31 |

Note: 1st means the initial winner. 2nd means the secondary winner. .

Tables 4a to 4c describe all types of contracts involving the three companies that have been tendered twice. For example, the second row of Table 4a suggests there are 59 contracts that were won by the same division of Go-Ahead twice. First, we investigate whether there is any evidence of the first kind of market sharing agreement that companies commit not to enter each other's territory. As we can see, for all the three companies, the number of type 1 contracts is obviously higher than type 3 contracts, which means that if a company wins a contract for the first time, it is more likely to win the same contract next time. On the other hand, type 3 and type 4 contracts are material for these companies. All of them keep losing old contracts and winning new contracts. In Table 5, Go-Ahead won 59 contracts twice, but only lost 1 contract to Arriva and 1 contract to ComfortDelGro separately. Arriva lost 12 contracts to Go-Ahead while ComfortDelGro didn't lose any contracts to these two companies. This provides insufficient information by itself to answer the question of whether they collude to stay away from each other's territory.

Table 6: Other information about the contracts won twice respectively by the three companies

| Company | Number of contracts | Average number of bidders | Average cost per mile, £ | Average price increase |
|---|---|---|---|---|
| Go-Ahead | 59 | 2.51 | 3.87 | 2.8% |
| Arriva | 62 | 2.79 | 3.68 | 3.4% |
| ComfortDelGro | 31 | 2.68 | 4.57 | 3.5% |
| Whole sample | 882/402 | 2.96 | 3.73 | 3.9% |

Note: For price increase, we only have information for 402 contracts since only 402 contracts have been tendered twice or more.

In Table 6, we see that for the 59 contracts won twice by Go-Ahead, there are 2.51 bidders on average for each contract, lower than the sample average: in general fewer bidders participate in these 59 auctions. But if the first kind of market sharing collusion exists, we could expect significantly higher average cost per mile and higher average price increase. In other words, Go-Ahead would feel confident in raising the price given it knows that other companies won't enter its territory. However, the data in the table above does not support that. The reasoning is similar for Arriva. For ComfortDelGro, the average cost per mile is very high, but this mainly stems from the outlier, Route 143D. If we exclude this outlier, the average cost per mile would be £3.93. It seems there is no obvious evidence of the first kind of market sharing agreement.

Then we examine the second kind of market sharing agreement. We focus on type 3 and type 4 contracts to analyse whether they collude to exchange contracts. For the 15 contracts that Go-Ahead lost, they were won by 7 different bus companies, quite diversified. For the 24 contracts that Arriva lost, they were won by 9 different bus companies. ComfortDelGro also lost 8 contracts to 5 different companies. If we count different divisions, it would be even more diversified. For type 4 contracts, all of the three companies also won new contracts from reasonably different companies. One thing we notice is that all of them won several contracts from First Group. This is because First left the London bus market in 2012. If they collude to exchange contracts, then we can observe that two companies win contracts systematically from each other. Based on Table 5, we can see that it is not very symmetric. Although Arriva lost 12 contracts to Go-Ahead, it only won 1 contract from Go-Ahead. There is no evidence of exchanging contracts between two companies. Although we only examine data involving the three companies, if there is any collusion between a small company and any of the three companies, it will also be reflected in our data. But we can't find any evidence of the second kind of market sharing agreement.

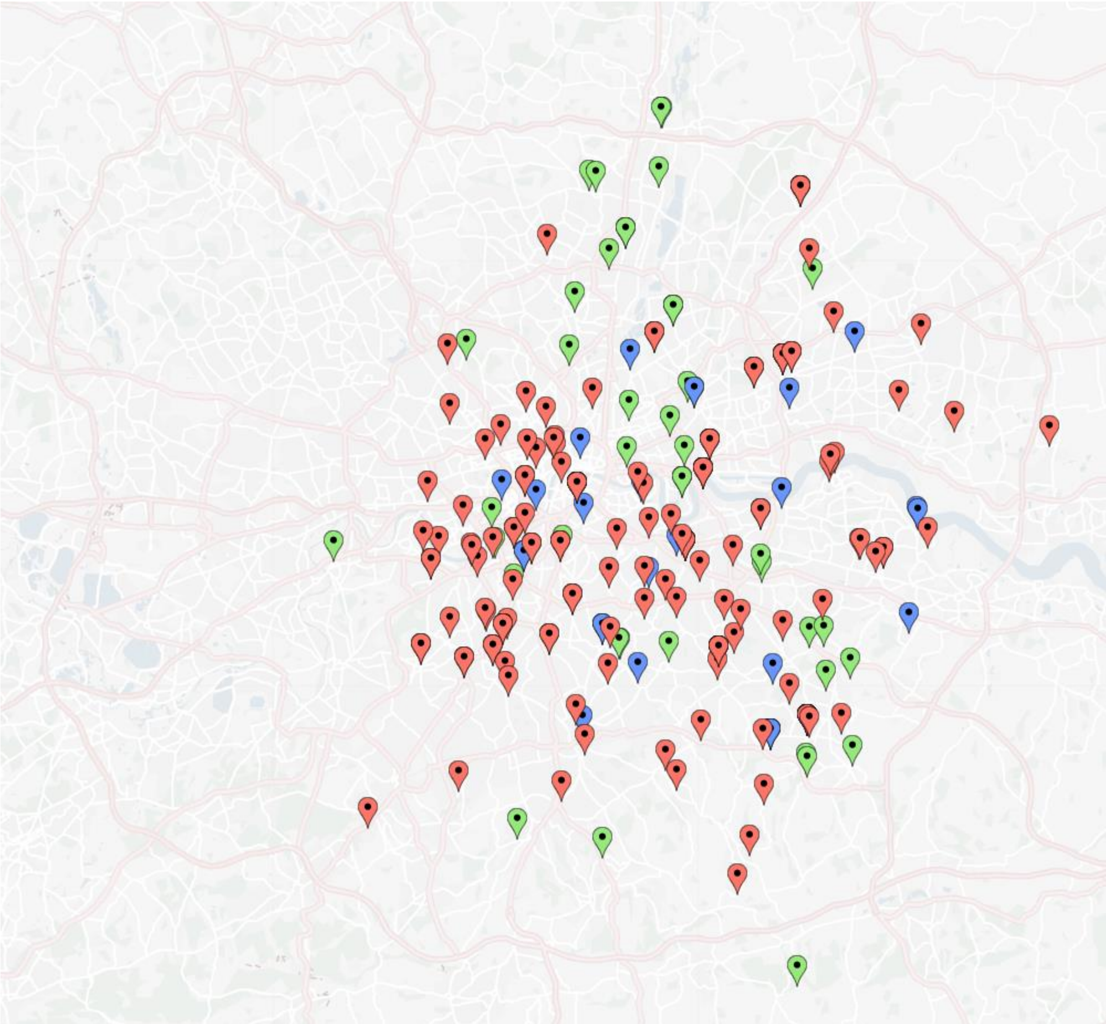
**Proposition 2A: Entering each other's territory is not uncommon among operators. We cannot find evidence of the first kind of collusion by market sharing.**
**Proposition 2B: We cannot find evidence of exchanging contracts, the second kind of collusion by market sharing.**

There could also be some other kinds of collusion by market sharing that are more difficult to detect. For instance, two of those companies operate buses not only in London, but also in other areas of UK. Some of them even play a role in the train market. Collusion by market sharing among different markets is not unrealistic. Some bus company may sacrifice part of its market share in London in exchange for market share in other places provided by another bus company. This won't be reflected in our data set. However, ComfortDelGro is not affected by this caveat.

As a further investigation, in making comparisons between routes won and routes lost, one possibility would be that companies come to dominate particular geographic area. They strategically lose some routes and bid fiercely for some other routes in order to improve their market concentration. We use three figures below to test the hypothesis.

**Hypothesis 3: Operators strategically bid for routes to improve their market concentration and dominate particular geographic area in London.**

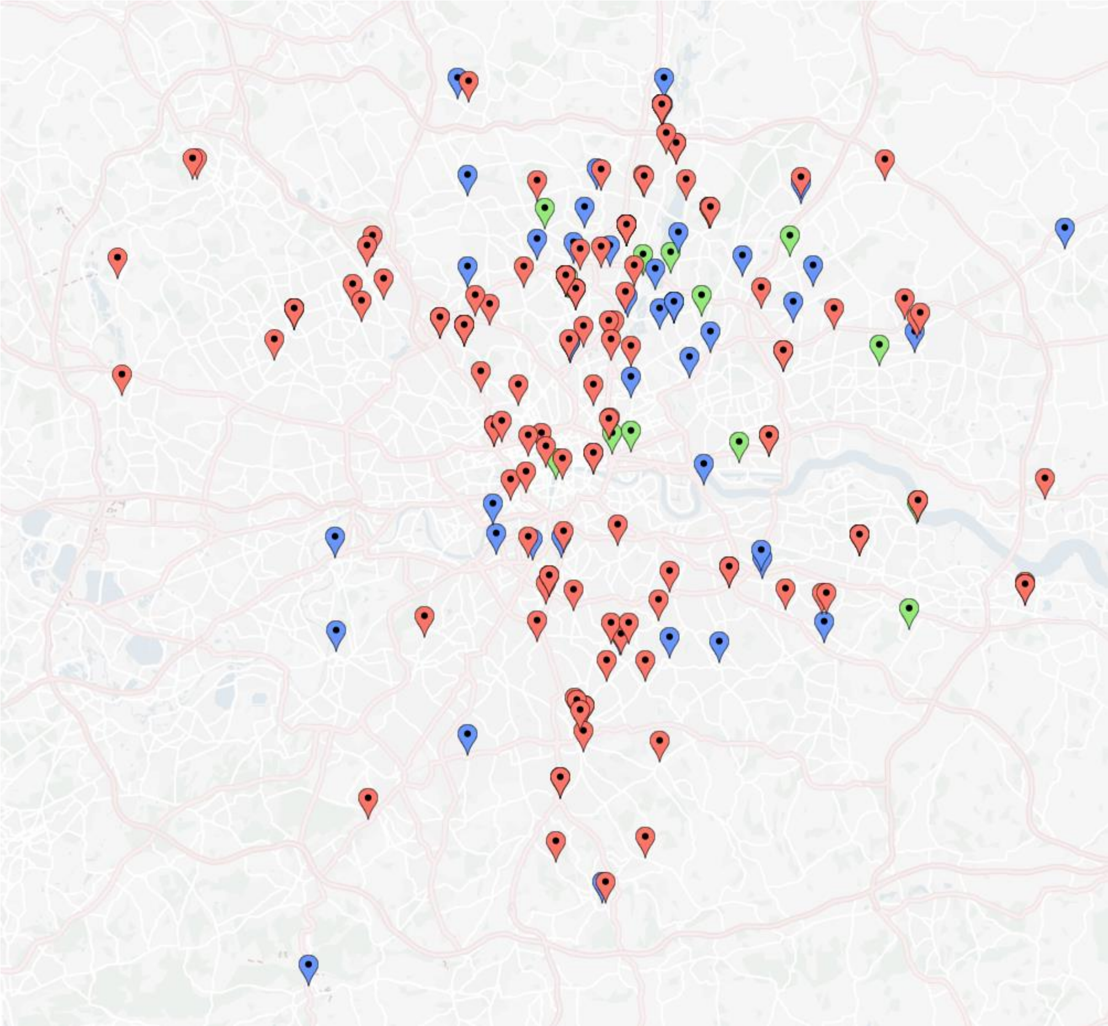
Figure 9: The endpoints of routes involving Go-Ahead that have been tendered twice



Key: Each route has two endpoints. Red marks represent the endpoints of type 1 and type 2 routes of Go-Ahead. Blue marks represent the endpoints of type 3 routes of Go-Ahead. Green marks represent the endpoints of type 4 routes of Go-Ahead. If several endpoints share the same address, there is only one mark.

As we can observe from Figure 9, Go-Ahead focuses on the central and eastern parts of London. It was also expanding its business toward north and south (green marks). But few of its routes are in the western half. The routes it lost (type 3 routes) are obviously fewer than the routes it newly acquired (type 4 routes).

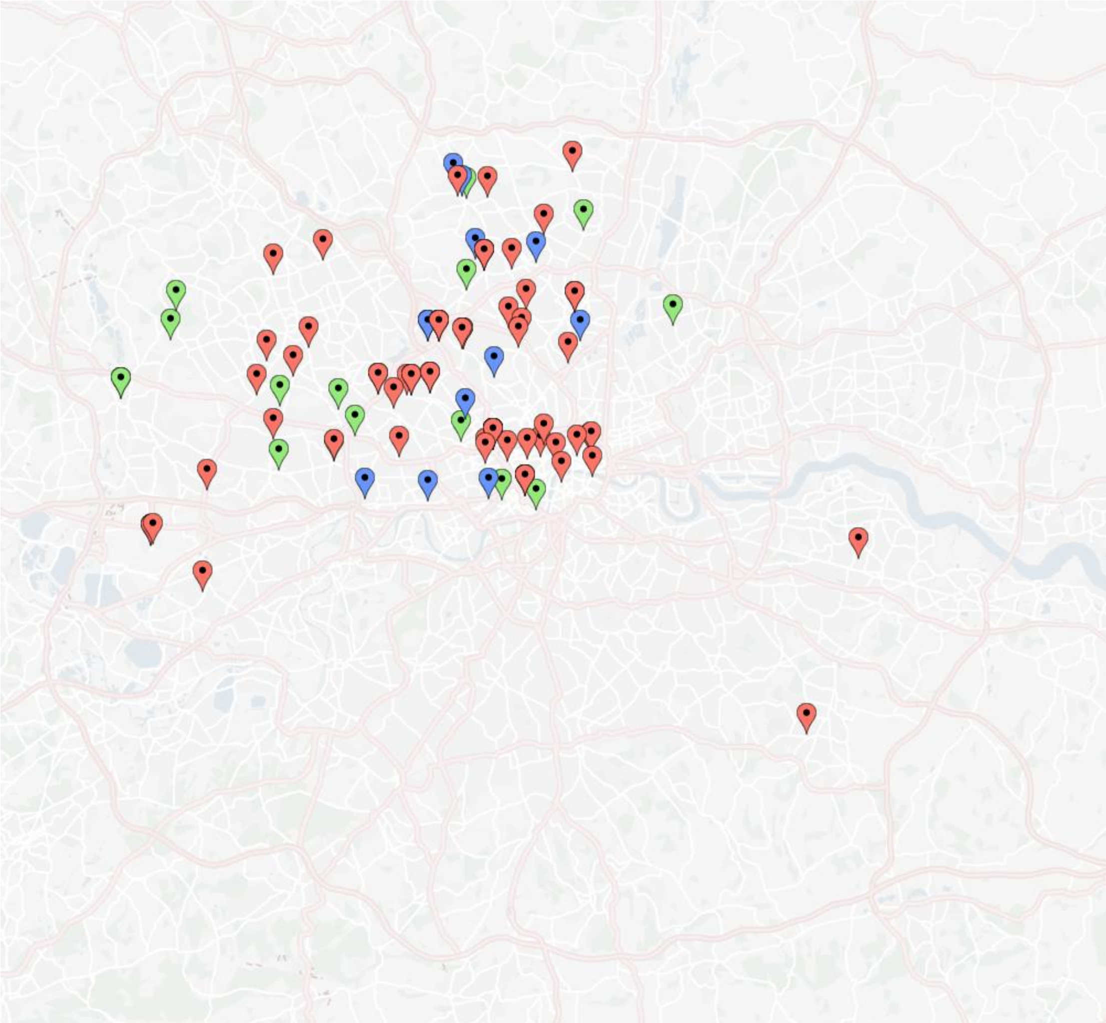
Figure 10: The endpoints of routes involving Arriva that have been tendered twice



Key: Each route has two endpoints. Red marks represent the endpoints of type 1 and type 2 routes of Arriva. Blue marks represent the endpoints of type 3 routes of Arriva. Green marks represent the endpoints of type 4 routes of Arriva. If several endpoints share the same address, there is only one mark for them.

Figure 10 repeats this exercise for Arriva. The locations of endpoints of routes involving Arriva are quite scattered. It operates routes in almost all parts of London, with fewer routes in the Southwest and Southeast. General speaking, it has more routes in northern London. It lost plenty of routes (blue marks) in both northern and southern London. However, for the routes it newly won (green marks), most of them are in northern London.

Figure 11: The endpoints of routes involving ComfortDelGro that have been tendered twice

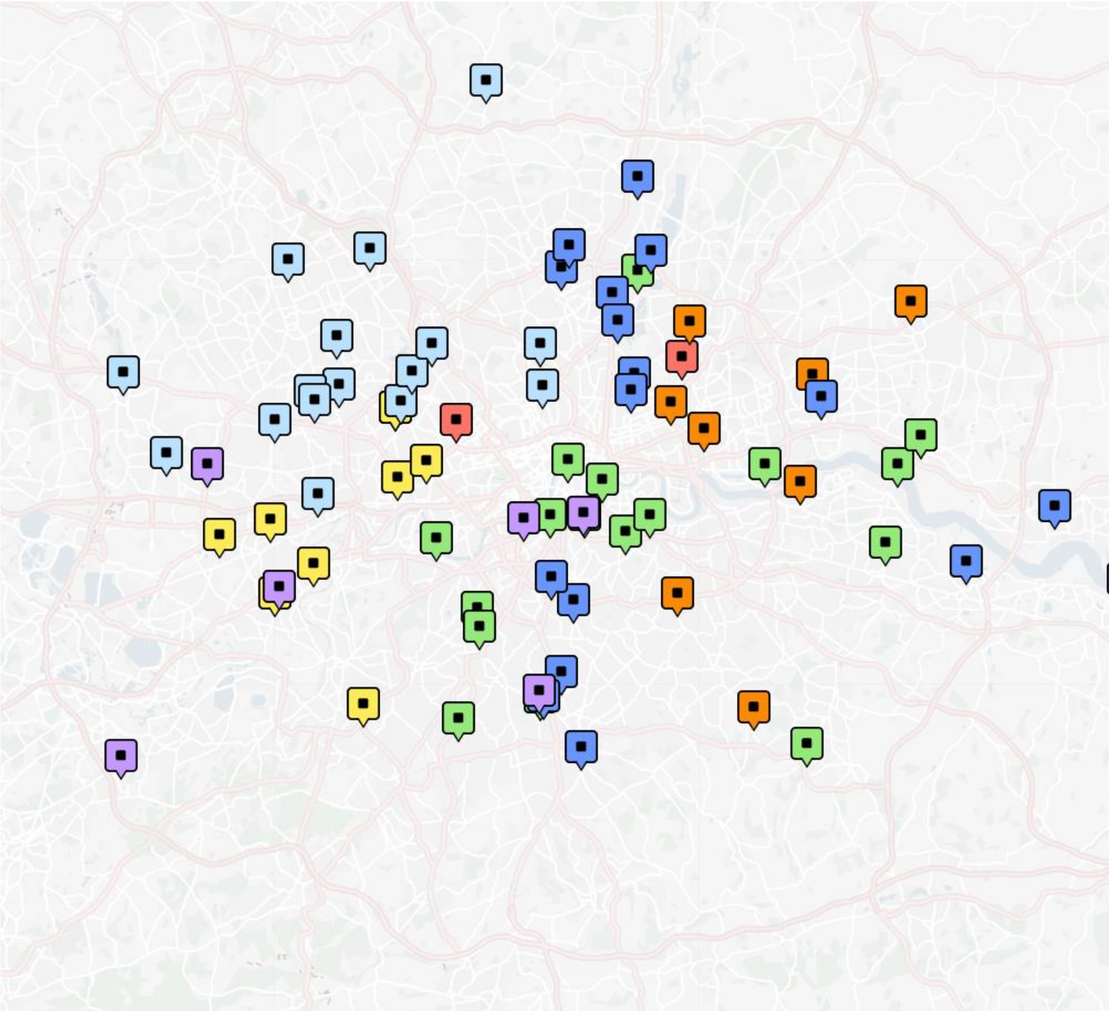


Key: Each route has two endpoints. Red marks represent the endpoints of type 1 and type 2 routes of ComfortDelGro. Blue marks represent the endpoints of type 3 routes of ComfortDelGro. Green marks represent the endpoints of type 4 routes of ComfortDelGro. If several endpoints share the same address, there is only one mark for them.

Finally, we repeat the exercise for ComfortDelGro in Figure 11. Almost all of the routes of ComfortDelGro are in the North-western part of London, very few of them are outside this part. The routes it lost or newly acquired are also in this area. ComfortDelGro concentrates on the market in North-western London.

From the three figures above, we find two of these bus companies mainly focus on some certain area of London, they operate routes in some particular parts of London. According to Iossa and Waterson (2019), one important reason for a bus company to bid for a route is whether it has a garage nearby. The locations of their garages affect which area they operate routes. In order to make our analysis more comprehensive, we use Figure 12 below to mark the garages in London for all of the major operators.

Figure 12: The locations of garages of different bus companies in London



Key: Green: Go-Ahead; Deep blue: Arriva; Light blue: ComfortDelGro; Orange: Stagecoach; Yellow: RATPDev; Purple: Abellio; Red: Tower Transit. There are several garages outside the map area so not illustrated here.

As expected, the garages of Go-Ahead are mainly in central and Eastern London, while ComfortDelGro's garages basically locate in North-western London. The distribution of their garages is similar with the distribution of the endpoints of routes they operate. However, Arriva's garages are not as scattered as its endpoints; most of them are roughly on a North-South axis across London. From the position of their garages, we can basically infer that Stagecoach operates buses mainly in the Eastern part of London. RATPDev and Abellio focus more on the South-western market.

This suggests that the bus companies still need to compete with others having nearby garages. For example, Arriva, Go-Ahead and Stagecoach are best-placed to fight for the market in Eastern London, while Arriva also competes with ComfortDelGro in North-western London. RATPDev and Abellio are both active in South-western

London. There are also some other small companies not illustrated here. Totally occupying the market in a certain area is not easy, it appears. Thus we conclude with:

**Proposition 3: Many operators concentrate on some particular parts of London, but there are still many overlaps between them. It is hard to say that any one company dominates a particular area.**

### 3.3 Evidence on the bid gap and Benford's Law

TfL publishes information about number of tenderers, lowest price, highest price, accepted price and the winner etc. for each route. Although we have no information about who failed in a tender, there are methods we can employ to analyse whether collusion exists or not. We first investigate the pattern of average bid gap percentage in Table 7. We define the bid gap percentage as the difference between the highest bid and the lowest bid over the lowest bid. According to Table 7, as the number of tenderers increases, the average bid gap percentage also increases throughout the range but the average bid gap percentage *per bidder* shrinks (except, trivially, for few very large bidder numbers cases). This is what would be expected from independent bidding. To put the alternative, if the average bid gap percentage with 2 tenderers is significantly higher than that of 3 or more tenderers, then it is possible that some pairs of tenderers collude on the bids, implying that one of them bid truthfully, while another one just participates and gives a random high price. The standard deviation of the bid gap percentage rises when there are less than 6 bidders, against a rule-based formulation of the losing bids. For cases of more than 5 tenderers, collusion is likely to be very difficult as it is not easy to reach agreement among so many companies.

Table 7: Information on number of tenderers and their average bid gap percentage

| No. of bidders | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Average bid gap percentage | 0 | 0.092 | 0.152 | 0.208 | 0.252 | 0.267 | 0.291 | 0.36 |
| Average bid gap percentage per firm | 0 | 0.092 | 0.076 | 0.069 | 0.063 | 0.053 | 0.048 | 0.051 |
| Standard error | 0 | 0.101 | 0.154 | 0.16 | 0.174 | 0.148 | 0.152 | 0 |
| No. of auctions | 64 | 256 | 312 | 171 | 64 | 11 | 3 | 1 |

Key: bid gap percentage= (highest bid – lowest bid)/lowest bid.

Figure 13: Average bid gap percentage over time

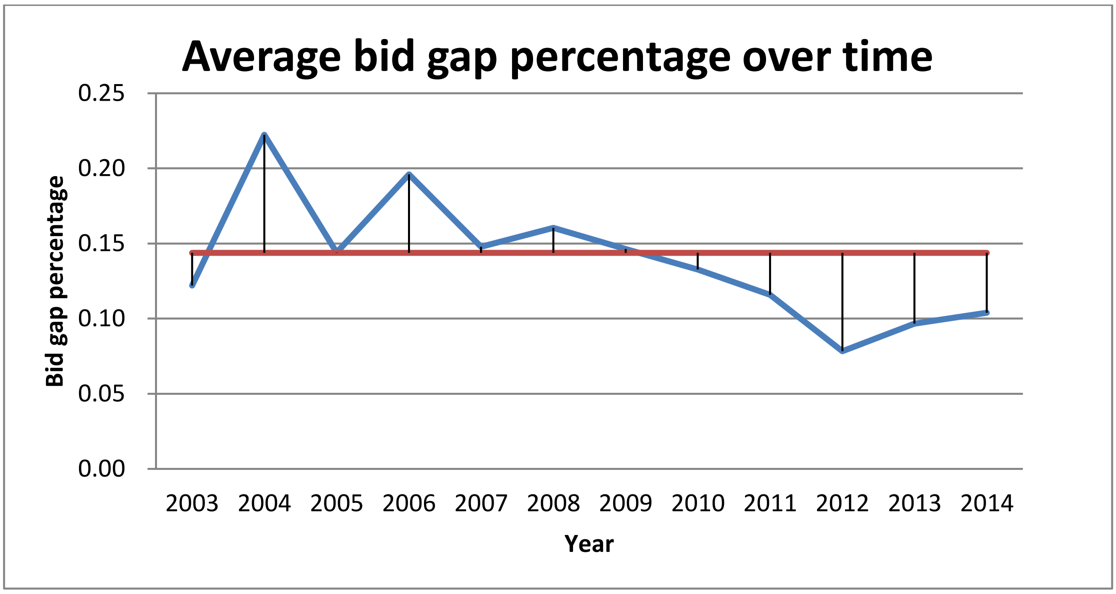



Figure 13 demonstrates the average bid gap percentage in each year. The sample average is 0.14 (the red line). Most of the average bid gap percentages before 2009 are above the sample average. It declined to 0.08 in 2012. Bid gap percentage is mainly determined by number of bidders if there is no collusion. Before 2009, there were more bus operators in the market, so we can expect higher average bid gap percentage. From 2003 to 2014, the number of bus companies in the market had been decreasing in general, which plausibly led to the decreasing trend of yearly average bid gap percentage.

We now turn to the role of Benford's law (Hill, 1995). This "law" is commonly used to examine administrative numbers or constructed numbers in accounting, finance or other activities for potential fraudulent activity. If a distribution conforms to Benford's law, then the data can be said to arise from a set of naturally-occurring numbers, whereas deliberately constructed numbers tend not to conform. This is because people constructing numbers commonly assign roughly equal probabilities to each digit appearing, whereas, particularly as regards the first digit in a natural number distribution, the digits 1 and 2 appear far more often.[9] Tables of relative and expected frequencies can be calculated, and we make use of this information below.

Here we employ it to test collusion. Benford's law asserts that the frequency distribution of the first digits from numerical data of natural processes conforms to a

[9] Quite what constitutes a "natural number" is not completely clear. Examples like the lengths of rivers or the populations of countries comply with this pattern, whereas numbers of pages in a book do not. Nor do any numbers where there is deliberate construction of the number.

certain pattern whereby the digit 1 occurs around 30% of the time, the digit 2 around 17.6% of the time, etc. The second digit, third digit etc. also follow other certain different distributions. However, for manipulated data, the distribution of its digits is usually different from the distribution proposed by Benford. Scholars often use a first digit test, second digit test or first two digits test to examine data. Hence, we have:

**Hypothesis 4: Bid gap numbers deviate from Benford's law, which is evidence of collusion and manipulation.**

Notice that we focus on the size of the gap (the highest bid minus the lowest bid) between bids. This is deliberate; the winning bids for bus routes are unlikely to conform to the idea of natural numbers, because the routes themselves are constructed by TfL, and so particular route sizes/ frequencies may dominate. Hence by extension, if one company sets the winning bid and another agrees to set a price say 10% above that, the gap itself will equally not conform to Benford's law. By contrast, if the gap is due to different circumstances in different cases, then this is much more likely to conform to Benford's Law. Of course, we can only carry out this test on cases where there is more than one bidder.

Considering the gap between highest and lowest bids across the 806 available cases, Table 8 shows the results of the first digit test. The percentage of bid gap numbers decreases gradually as the first digit increases. Performing a chi-squared test, the calculated value is 17.5 (the 1% critical value in this case is 20.09 and the 5% critical value is 15.51), which confirms the deviation of the sample, but not to a 1% significant level. The biggest deviation occurs when the first digit is 1, where it is 3.9% *lower* than Benford's set. Correspondingly, when the first digit is 3, the percentage of the bid gap number is 3.5% higher than Benford's set. The alternative Z-statistic test provides an alternative method to test the goodness of fit. The critical value for a 5% level of significance is 1.96. In table 8, Z-statistics for the first digits 1, 3 are above the critical value. For other first digits, Z-statistics are below the critical value. However, being significant does not necessarily mean being abnormal. The result could also stem from the misuse of Benford's law, limited sample size or excess power problem. To further examine the bid gap numbers, we concentrate on the cases with first digits being 1 and 3.

Table 8: First digit test proportions

| First digit | Bid gap numbers | Benford's set | Deviation | Z-statistic |
|---|---|---|---|---|
| 1 | 26.2% | 30.1% | -3.9% | **2.39** |
| 2 | 19.2% | 17.6% | 1.6% | 1.17 |
| 3 | 16.0% | 12.5% | 3.5% | **2.96** |
| 4 | 10.0% | 9.7% | 0.3% | 0.28 |
| 5 | 8.8% | 7.9% | 0.9% | 0.89 |
| 6 | 6.7% | 6.7% | 0.0% | -0.07 |
| 7 | 5.0% | 5.8% | -0.8% | 0.94 |
| 8 | 4.1% | 5.1% | -1.0% | 1.22 |
| 9 | 4.0% | 4.6% | -0.6% | 0.77 |

When the first digit is 1, the average cost per mile is £3.74. When the first digit is 3, the average cost per mile is £3.52. Both are similar to or lower than the sample average £3.73. The average of numbers of tenderers for these two cases are 3.09 and 3.12 respectively, slightly higher than the sample average 2.96, which suggests the competition is even fiercer for these two cases. And the winners of the contracts for these two cases are sufficiently diversified amongst firms. If there is any collusion, either we would see very few winners, a lower number of tenderers or higher cost per mile. But the evidence is against our initial hypothesis.

In a more detailed investigation, we also employ Benford's law to compare the bid gap results of auctions with 2 bidders and 3 bidders. We do not consider auctions with more bidders here because the sample sizes are small. The tables below show the result. As can be seen from Tables 10 and 11, the bid gap of auctions with 2 bidders conforms to Benford's law substantially better. The chi-squared statistic here is only 10.1 (1% critical value is 20.09, 5% critical value is 15.51). The Z-statistic is significant only when the first digit is 5. For auctions with 3 bidders, the chi-squared statistic is 16.6, we cannot reject the hypothesis that it deviates from the Benford's law at the 5% significant level. The Z-statistic is significant when the first digit is 3. Actually, this is what we would expect under the alternative hypothesis that there is no collusion. The gap between the first and the third bid is the sum of two numbers, whilst the gap between first and second is just a single value, and so more likely to conform to the "natural number" concept.

Table 10: First digit test for bid gap of auctions with 2 bidders

| First digit | Bid gap numbers | Benford's set | Deviation | Z-statistic |
|---|---|---|---|---|
| 1 | 26.2% | 30.1% | -3.9% | 1.28 |
| 2 | 16.3% | 17.6% | -1.3% | 0.47 |
| 3 | 14.3% | 12.5% | 1.8% | 0.76 |
| 4 | 9.5% | 9.7% | -0.2% | -0.01 |
| 5 | 12.7% | 7.9% | 4.8% | **2.71** |
| 6 | 5.6% | 6.7% | -1.1% | 0.60 |
| 7 | 6.0% | 5.8% | 0.2% | -0.03 |
| 8 | 5.2% | 5.1% | 0.1% | -0.10 |
| 9 | 4.4% | 4.6% | -0.2% | 0.03 |

Note: 252 effective auctions

Figure 14: First digit test for bid gap of auctions with 2 bidders

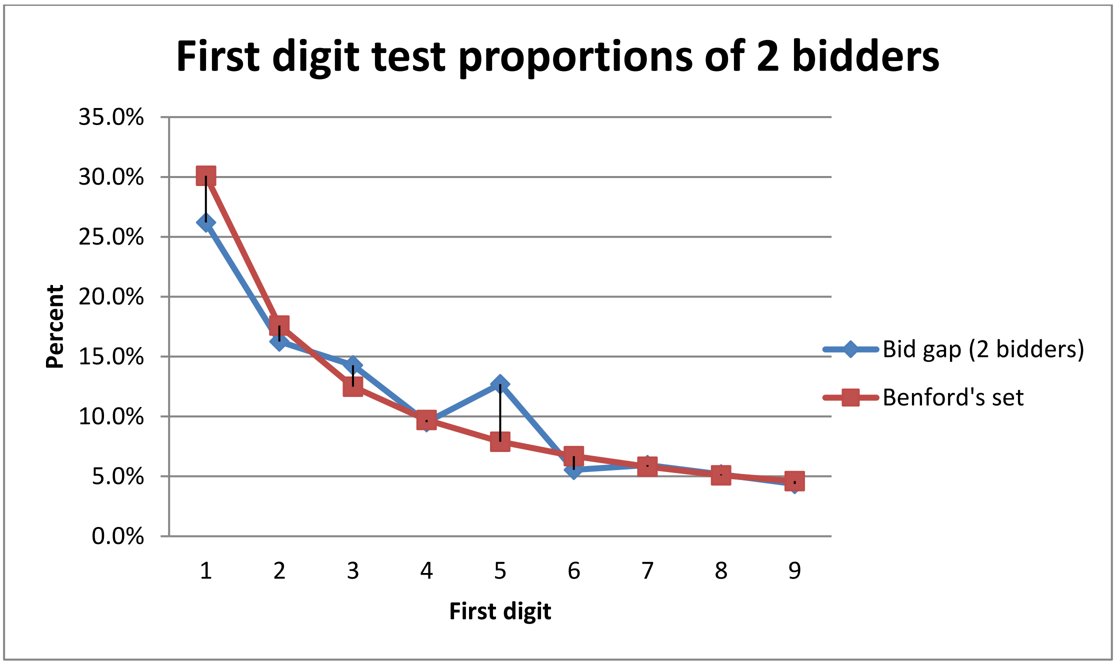



Table 11: First digit test for bid gap of auctions with 3 bidders (307 effective auctions)

| First digit | Bid gap numbers | Benford's set | Deviation | Z-statistic |
|---|---|---|---|---|
| 1 | 28.7% | 30.1% | -1.4% | 0.49 |
| 2 | 21.8% | 17.6% | 4.2% | 1.87 |
| 3 | 17.3% | 12.5% | 4.8% | **2.44** |
| 4 | 9.1% | 9.7% | -0.6% | 0.25 |
| 5 | 5.2% | 7.9% | -2.7% | 1.64 |
| 6 | 7.2% | 6.7% | 0.5% | 0.21 |
| 7 | 3.6% | 5.8% | -2.2% | 1.54 |
| 8 | 3.9% | 5.1% | -1.2% | 0.82 |
| 9 | 3.3% | 4.6% | -1.3% | 0.99 |

For auctions with 2 bidders and 3 bidders, their average costs per mile are £3.75 and £3.68 respectively, quite close to the sample average £3.73. For auctions with 3 bidders, it is even lower than the sample average.

More forensically, let us focus on the anomalies of the bid gap of auctions with 2 bidders first. As we have mentioned before, the only significant first digit is 5. There are 32 bid gap numbers beginning with 5. They belong to very different routes won by different companies. The dates of these 32 auctions range from 2003 to 2014. The average cost per mile is £3.69, lower than the sample average. No specific pattern has been found, showing no evidence of collusion here.

Then we examine auctions with 3 bidders further, which leads us to the case where the first digit is 3. There are 53 auctions with bid gap numbers beginning with 3. After calculation, we find the average cost per mile among these 53 auctions is £3.42, significantly lower than sample average £3.73. This suggests that collusion is very unlikely here.

**Proposition 4: There are a few cases where bid gap numbers deviate from Benford's law, but other evidence does not support the existence of collusion or manipulation.**

### 3.4 Examination of the "worst bid"

How might we define a "worst bid"? A "worst bid" is usually an expensive bid; it is natural to think of the bid with the highest cost per mile. The route with highest cost per mile is W13D. However, it only has about 1750 miles, a rather short route compared with other routes. Most of the routes have more than 100,000 miles, but all the top 10 routes with highest cost per mile are below 100,000 miles. Plausibly, where the route is short, the cost per mile is higher, as we have proved in Table 3.

Alternatively, the price ratio could be a more appropriate reference. This is the price of the second contract over the price of the first contract with the first price uprated to the second date according to the formula for cost increases. It equals to new to old contract price we calculated in section 2.5. Then we are comparing the price of the same route, thus eliminating the price difference caused by different route characteristics. A tender with a high price ratio means it becomes more expensive than previously. This suggests a definition of a "worst bid" as a bid with the highest price ratio. We summarise the "worst bids" in Table 12.

Table 12: Information about bids with the highest price ratio

| Route | Tenderers | Winner | Cost/m £ | Bid gap | Price ratio | Package bid |
|---|---|---|---|---|---|---|
| W11 | 4 | Arriva London | 4.23 | 23.2% | 1.89 | N/A |
| 257 | 3 | Blue Triangle | 4.68 | 9.3% | 1.53 | N/A |
| 15H | 2 | East London | 12.90 | 0.4% | 1.43 | N/A |
| 9H | 2 | First London | 14.74 | 9.7% | 1.39 | N/A |
| 187 | 3 | West | 3.65 | 12.2% | 1.35 | Yes |
| B15 | 3 | First Centre | 3.51 | 9.3% | 1.32 | Yes |
| W10 | 3 | West | 6.60 | 27.1% | 1.30 | N/A |
| 372 | 3 | Arriva | 2.66 | 17.1% | 1.30 | Yes |
| 122 | 2 | First London | 3.85 | 22.6% | 1.29 | N/A |
| 223 | 3 | East | 3.93 | 12.0% | 1.27 | N/A |
| | | Stagecoach | | | | |
| Mean | 2.8 | Stagecoach | 6.08 | 14.3% | 1.41 | |
| | | Selkent | | | | |
| | | First London | | | | |
| | | West | | | | |

Table 12 indicates that the winners of the "worst bids" are quite different. Their cost per mile is comparably higher, especially for 15H and 9H. These are "heritage" routes using special old buses. For these 10 routes, their high price ratio is partly because they are not package bids, although nor are many others. Route W11 has significantly higher price ratio than others. When we examined it carefully, we found that this tender was announced on 21 July 2011. It wan not awarded to the lowest bid because that bid was withdrawn. Then we examined all the tenders announced on 21 July 2011. Surprisingly, among the 21 tenders announced on that day, there were 11 cases where they didn't award to lowest bid because of bid withdrawn! This is very abnormal since bid withdrawn is not common on other dates. In our sample of 882 cases, 227 of them have an accepted bid higher than the lowest bid. Most of them are because higher quality was expected, a better package bid was submitted (this is by far the most common reason by far; Iossa and Waterson (2019) find this accounts for over 14% of total bids in their sample) or the incumbent's good performance. Table 13 summarizes the information related to 21 July 2011.

**Hypothesis 5: The high frequency of bids withdrawn on 21 July 2011 is because of collusion.**

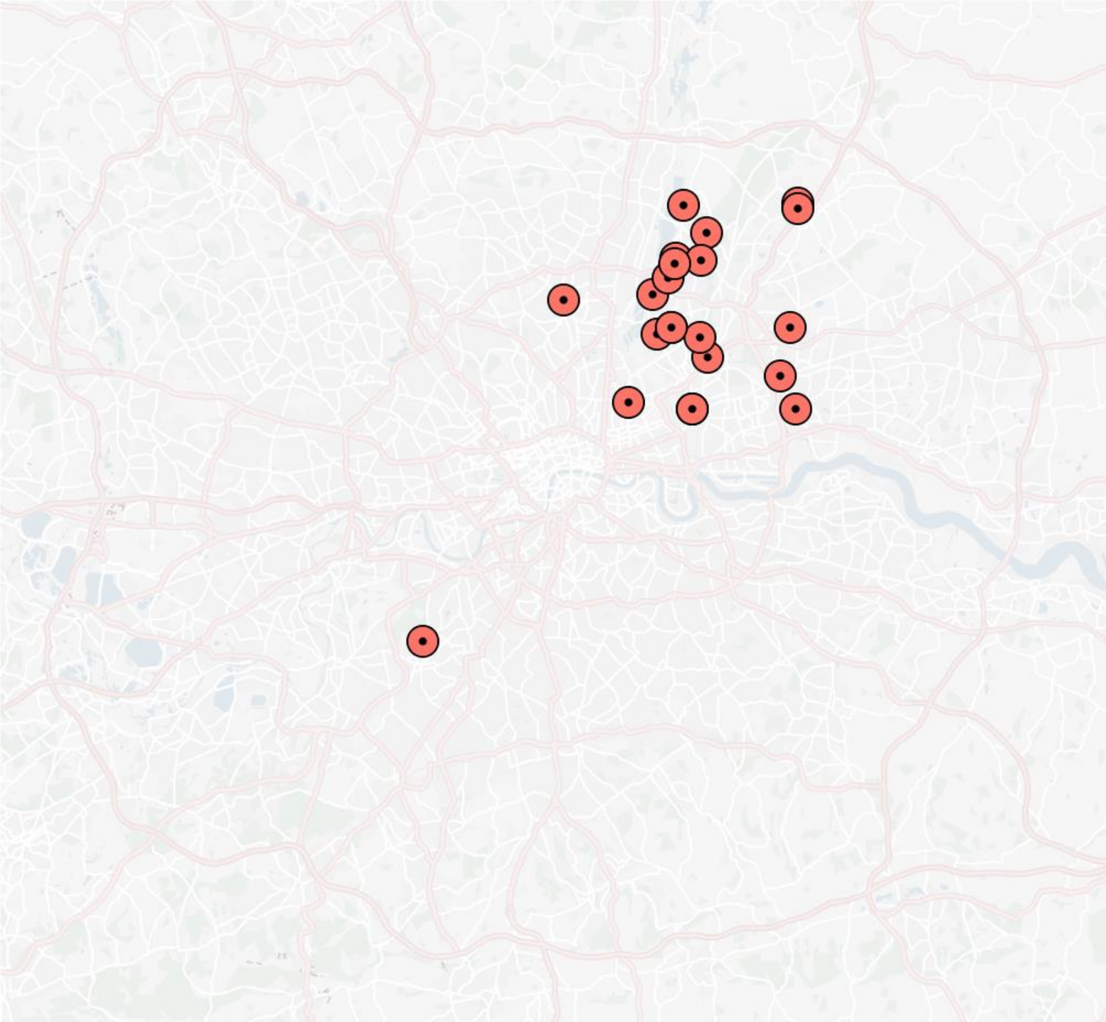
Table 13: Tenders announced on 21 July 2011 that do not award to lowest bid because of bid withdrawn

| Route | Bidders | Winner | Previous operator | Cost/m £ | Bid gap | Price ratio |
|---|---|---|---|---|---|---|
| 20 | 4 | Blue Triangle | Arriva London | 3.61 | 16.3% | 1.20 |
| 123 | 4 | Arriva London | Arriva London | 3.76 | 9.7% | 1.19 |
| 158 | 4 | Stagecoach | Stagecoach | 4.00 | 13.8% | 1.13 |
| 238 | 3 | Stagecoach | Stagecoach | 5.24 | 12.0% | 1.19 |
| 275 | 3 | Stagecoach | Arriva London | 3.46 | 19.5% | 1.13 |
| 357 | 4 | First London | First Capital | 4.77 | 29.6% | 1.23 |
| 379 | 2 | East | Arriva London | 3.82 | 21.2% | 1.07 |
| 397 | 2 | Arriva London | Arriva London | 3.93 | 20.7% | 1.07 |
| W11 | 4 | Arriva London | Arriva London | 4.23 | 23.2% | 1.89 |
| W15 | 3 | Arriva London | Arriva London | 3.71 | 21.5% | 1.23 |
| W16 | 3 | First London East | Arriva London | 3.69 | 17.5% | 1.07 |
| Mean | 3.27 | First London East | | 4.02 | 18.6% | 1.22 |

Almost all these routes are in the North-eastern part of London- see Figure 16. For all the 11 tenders, average bidder numbers at 3.27 are higher than the sample average 2.96, which could suggest a competitive environment here. But the other three indicators are obviously larger than sample average (£4.02 vs £3.73, 18.6% vs 14.0%, 1.22 vs 1.04). We can see a sharp price increase here with bid withdrawn, with all 11 cases having a price ratio higher than sample average. If there is no bid withdrawn, the price increase would be less significant because otherwise bidders with the lowest price would win. More importantly, all the 11 bids withdrawn happened on the same day with a withdrawal rate higher than 50%. Therefore, this is a somewhat anomalous situation. One possibility is that those bus companies colluded to withdraw the lowest bid they gave to those routes. However, there could be other possibilities such as some companies decided to quit the market suddenly and withdrew all their bids on those routes.

**Proposition 5: The high frequency of bid withdrawn on 21 July 2011 coincides with high cost per mile and high price ratio, implying that collusion among bidders is possible on that day.**

Figure 15: The endpoints of the 11 routes that do not award to lowest bid because of bid withdrawn



**3.5 Capacity issues and changing hands- is there evidence of stasis?**

When it comes to capacity issues, one hypothesis is that large routes in terms of bus miles will attract fewer bidders. As such, they may be more prone to small number situations, and possibly collusion. This is because large routes usually require more buses to fulfil the contract and higher garaging and other costs, which smaller bus companies cannot afford.

**Hypothesis 6: Fewer bidders will participate in tenders involving large routes in terms of bus miles.**

As we can see in Table 14, except for the last row, the average number of bus miles decreases with the number of bidders. Therefore, suggests the existence of asymmetries among bidders. The competition on smaller routes is usually fiercer.

Table 14: number of bidders and average bus miles

| Number of bidders | Number of auctions | Average bus miles (10,000) | Average accepted bid (million £) | Average cost per mile |
|---|---|---|---|---|
| 1 | 64 | 65.37 | 2.75 | 4.71 |
| 2 | 256 | 54.56 | 2.08 | 3.75 |
| 3 | 312 | 54.09 | 1.98 | 3.68 |
| 4 | 171 | 51.21 | 1.79 | 3.48 |
| 5 | 64 | 42.44 | 1.45 | 3.52 |
| 6 | 11 | 32.59 | 1.15 | 4.51 |
| 7 | 3 | 23.78 | 0.81 | 3.47 |
| 8 | 1 | 57.97 | 1.56 | 2.69 |

Note: The average accepted bids have been adjusted by the price index.

On the other hand, Table 15 provides information from another perspective. If we divide bus miles into different levels, we see that actually there are more bidders on average for routes with middling bus miles, namely 400-600 thousand miles. For larger routes, as we explained before, not every bus company has enough capacity to operate, thus they have fewer bidders. But why do smaller routes also have fewer bidders? One possible explanation is that bidding costs are a higher proportion of contract value for small routes, so that it is less worthwhile to put in a bid.

**Proposition 6: Both large routes and small routes have fewer bidders. Middle routes have more bidders on average.**

Another interesting phenomenon is that the percentage of package bids for very small bus routes is apparently lower than that of large routes. It is only 31.5% for routes with bus miles less than 100 thousand, less than a half compared with routes that have more than 500 thousand bus miles. Why is it that tenderers are reluctant to include small routes in a package? First, there are special routes among these short routes. For example, there would be no reason for a joint bid with a Heritage route, since they use different vehicles. Second, package bids clearly have to fit together as a package in order to make economic sense, and possibly lumping in a small route with a much larger one does not make sense.

Table 15: Information on different level of bus miles

| Bus miles (10000) | Number of auctions | Average number of bidders | Average cost per mile | Percentage of joint bid |
|---|---|---|---|---|
| <10 | 54 | 2.81 | 5.74 | 31.5% |
| 10-20 | 56 | 3.07 | 3.54 | 53.6% |
| 20-30 | 85 | 3.07 | 3.40 | 60.9% |
| 30-40 | 115 | 3.01 | 3.47 | 75.2% |
| 40-50 | 129 | 3.21 | 3.38 | 58.8% |
| 50-60 | 131 | 3.22 | 3.63 | 71.0% |
| 60-70 | 86 | 3.09 | 3.60 | 72.5% |
| 70-80 | 69 | 2.80 | 3.75 | 68.3% |
| 80-90 | 41 | 2.37 | 3.64 | 73.3% |
| 90-100 | 55 | 2.60 | 3.87 | 74.5% |
| >100 | 61 | 2.38 | 4.18 | 72.1% |

If there are fewer bidders compete for very large routes, does it mean that large routes change hands less often. We chose the 20 largest routes in Table 16 and found that only 4 of them changed hands. Recall that in our sample of 402 cases, there are 198 new entrants. It demonstrates that the frequency of changing hands for those 20 largest routes is rather low. Is it possible that those companies collude here to remain to be the incumbents of those large routes? To look into this, we examined the price increase among those 20 cases. If there is any collusion about continuance, the price increase here should be significantly higher than sample average. However, the average price increase in these 20 cases is only 0.58%, far below the sample average 3.9%.

Table 16: The 20 largest bus routes and their information about changing hands

| Routes | Bus miles (million) | Change hands | Routes | Bus miles (million) | Change hands |
|---|---|---|---|---|---|
| 25 | 2.37 | Yes | 149 | 1.20 | No |
| 29 | 1.66 | No | 134 | 1.19 | No |
| 73 | 1.63 | No | 102 | 1.19 | No |
| 140 | 1.36 | No | 96 | 1.18 | No |
| 53 | 1.35 | Yes | 96 | 1.16 | Yes |
| 59 | 1.31 | No | 243 | 1.14 | No |
| 12 | 1.26 | No | 472 | 1.14 | No |
| 279 | 1.24 | No | 472 | 1.12 | Yes |
| 36 | 1.21 | No | 43 | 1.10 | No |
| 176 | 1.20 | No | 453 | 1.09 | No |

Note: The 20 largest bus routes are among those have been tendered twice or more. The same route could differ slightly in length at a different time; we take the length when tendered for the latest time. Route 96 and route 472 appear twice as they each have been tendered for three times respectively.

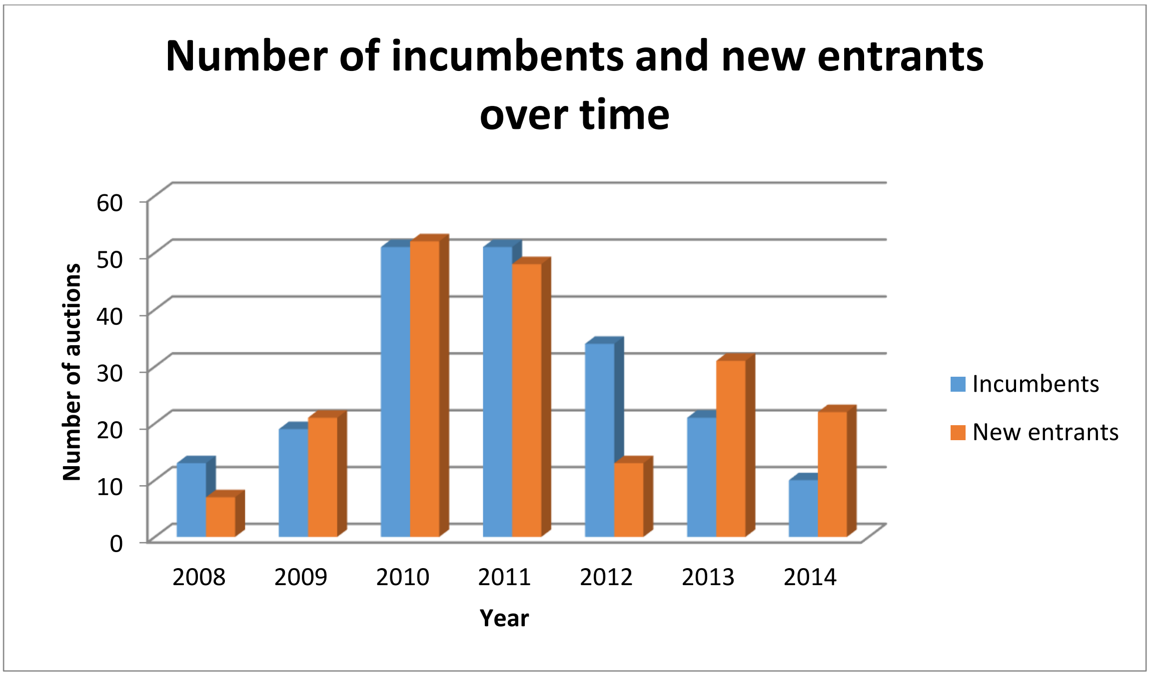
What types of routes most often change hands? This can be summarized from Table 17. Among the 402 cases, 198 routes have been won by a different company. As we expected, if there are more bidders or shorter bus miles, it would be easier to change hands. But the average cost per mile of new entrants is lower than that of incumbents. These two pieces of information suggest that incumbents mainly occupy higher total cost routes, which also can be inferred from average accepted bid. New entrants also have lower percentage of package bids and fewer average contract years. In terms of the higher price increase of new entrants, as we have analysed previously, it mainly stems from outliers.

Table 17: Information about incumbents and new entrants

| | Incumbents | New entrants |
|---|---|---|
| Number of cases | 204 | 198 |
| Average number of bidders | 2.67 | 3.03 |
| Average cost per mile, £ | 3.88 | 3.69 |
| Average bus miles (10000) | 57.2 | 50.2 |
| Average accepted bid (million £) | 2.20 | 1.82 |
| Percentage of joint bid | 67.5% | 52.0% |
| Average bid gap | 9.95% | 13.9% |
| Average price increase | 3.2% | 4.5% |
| Average contract years | 5.88 | 5.49 |

In addition, we also investigate in which year we have more new entrants among the 402 cases. In 2010, there were 52 new entrants to a route, the highest among those years. However, there were also 51 incumbents in 2010.The percentage of new entrants increased dramatically in 2013; it was 59.6%. And in 2014 it even reached 68.8%. It demonstrates that changing hands has become more common recently.

Figure 16: Number of incumbents and new entrants over time




Note: We ignore the data before 2008 because those years we only have one or two incumbents or new entrants, it is difficult to put them in the same picture.

We perform a logit regression to investigate the factors leading to changing hands. As we have mentioned before, number of bidders and bus miles will affect changing hands. We are going to examine these two variables. Cost per mile and different years are used as control variables. Table 18 below shows the result.

**Hypothesis 7: Number of bidders and bus miles play a role in affecting changing hands.**

Table 18： Logit regression to investigate factors leading to changing hands

| Variable | Coefficient | z-statistic | Significant level |
|---|---|---|---|
| number of bidders | 0.446 | 3.82 | 1% |
| ln(miles) (million) | -0.228 | -1.79 | 10% |
| cpm | -0.097 | -1.20 | Non |
| year | 0.102 | 1.66 | 10% |

Note: 401 observations, changing hands is a dummy variable, taking on the value 1 if it has changed hand.

If the number of bidders increases by one, the route would be 56.2% more likely to change hands after controlling other variables. If the bus route increases by 100%, the possibility of changing hands will decrease by 20.4% keeping other variables constant. And more recent years are also associated with more changing hands.

**Proposition 7: More bidders, shorter routes and more recent years will improve the possibility of changing hands.**

### 3.6 The Porter-Zona hypothesis

Finally, we examine the hypothesis proposed by Porter and Zona (1993, 1999) that those firms not expecting to win will put in "dummy bids" or "sham bids", not prepared on the basis of likely costs but instead just a rough round figure. The most likely case of this is for the worst bid on any occasion. This forms Hypothesis 8:

**Hypothesis 8: The worst bid will more often be a rounded bid than a carefully-prepared bid if the losing bidder has been determined beforehand.**

By examining the set of worst bids, we can uncover the frequency of bids which are in the round thousands of pounds as a proportion of all bids. We consider both the accepted bid and the highest bid (accepted bids are usually lowest bids, different from highest bids, except for the case of 1 bidder). First, we examine the number and frequency of rounded bid for different number of bidders as Table 19.

Table 19: Number and percentage of rounded bid for different number of bidders

| Number of bidders | Number of bids | Number of rounded accepted bids | Percentage of rounded accepted bids | Number of rounded highest bids | Percentage of rounded highest bids |
|---|---|---|---|---|---|
| 1 | 64 | 6 | 9.4% | 6 | 9.4% |
| 2 | 256 | 31 | 12.1% | 65 | 25.4% |
| 3 | 312 | 41 | 13.1% | 92 | 29.5% |
| 4 | 171 | 21 | 12.3% | 43 | 25.1% |
| 5 | 64 | 10 | 15.6% | 14 | 21.9% |
| 6 | 11 | 2 | 18.2% | 4 | 36.4% |
| 7 | 3 | 0 | 0.0% | 0 | 0.0% |
| 8 | 1 | 1 | 100.0% | 1 | 100.0% |

The rounded accepted bids is generally less frequent than the rounded highest bids, especially for the cases with 2-5 bidders (actually we don't have to consider cases with more than 5 bidders because of the limited sample size and the difficulty of collusion). However, in general, the percentage of rounded accepted bids is small. For the case of 2 bidders, the average cost per mile of the 31 rounded accepted bids is 3.73(for the cases of 3-5 bidders, the corresponding average costs are 3.67, 3.52, 3.98), showing no evidence of collusion.

Then we investigate the worst bids in terms of price increase (price ratio). We divide all the repeated bids into 5 intervals as in Table 20. The top 20% are the bids with highest 20% price increase (the average price increase for bids in this interval is 20.2%). For the bottom 80%-100% bids, their prices actually decrease (by 11.3% on average).

Table 20: Number of rounded bid for worst bids

| Worst bids interval | Number of rounded accepted bids | Percentage of rounded accepted bids | Number of rounded highest bids | Percentage of rounded highest bids |
|---|---|---|---|---|
| Top 20% | 18 | 22.4% | 27 | 33.6% |
| 20%-40% | 13 | 16.2% | 28 | 34.8% |
| 40%-60% | 15 | 18.7% | 23 | 28.6% |
| 60%-80% | 7 | 8.7% | 26 | 32.3% |
| 80%-100% | 9 | 11.2% | 28 | 34.8% |

Note: Total 402 observations because we can only consider repeated bids here.

According to Table 20, for bids with different levels of price increase, the percentage of rounded highest bids, though high, has no significant difference. However, the percentage of rounded accepted bids is higher for the top 20% worst bids. We run a regression to examine the relationship further.

Table 21: Regression to investigate whether rounded accepted bid is associated with higher price increase.

| Variable | Coefficient | t-statistic | Significant level |
|---|---|---|---|
| rounded bid | 0.006 | 0.37 | Non |
| change hands | 0.001 | 0.10 | Non |
| ln(miles) (million) | -0.013 | -1.92 | 10% |
| number of bidders | 0.005 | 0.76 | Non |
| joint | -0.037 | -2.92 | 1% |
| year | 0.017 | 4.91 | 1% |

Note: The dependent variable is the price increase. Rounded bid is a dummy variable equal to 1 if it is a rounded accepted bid.

Based on Table 21, the rounded accepted bid is not significantly associated with higher price increase (the result is still insignificant if we don't include other control variables). For bids showing price decrease, there are also some rounded accepted bids. As a result, there is no evidence of collusion involved with rounded bids.

**Proposition 8: Rounded bids are not scarce for different types of bids. The percentage of rounded highest bids is usually higher than the percentage of rounded accepted bids. But there is no evidence of collusion involved with rounded bids.**

## 4. Conclusions

We have engaged in a forensic investigation of the possibility of collusion playing a part within the context of contracts to procure bus services in London. Some data limitations meant we were not able to carry out certain tests. However, to the extent to which we can examine the outcomes, there is scant evidence that the firms collude in putting forward their bids. The most convincing evidence relates to withdrawn bids on one particular isolated date, and this is something worth investigating further.

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